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TRAINING AND DESIGN REQUIREMENTS FOR AN AIR FORCE
COMPUTER-AIDED TRAINING SUBSYSTEM FOR THE WORLD
WIDE MILITARY COMMAND AND CONTROL SYSTEM

A. K. Butler
R. J. Cooper
R. S. Cowdery
J. W. Cullen
K. E. Peterson

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30 September 1968

COMMAND SYSTEMS DIVISION
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

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FOREWORD

One of the goals of Air Force Electronic Systems Division is the development of design principles and specifications for automated training systems which could be built into Air Force information systems and used for on-the-job training of system personnel. Task 691709, Automated Training for EDP Personnel, under Project 6917, Command Management Data Systems Software, was established to develop the required technology and apply that technology in prototype computer-aided training systems built into Air Force computer-based information systems.

This report is one in a series supporting Project 6917, Task 691709. It presents initial requirements and design considerations for a computer-aided training system within the Department of the Air Force elements of the World-Wide Military Command and Control System (WWMCCS). Lt Joseph J. Solga served as Contract Monitor for this effort which was accomplished between 29 March 1968 and 30 July 1968.

The study was performed under Contract Number F19628-68-C-0323 with System Development Corporation by A. K. Butler, R. J. Cooper, R. S. Cowdery, K. E. Peterson and J. W. Cullen, principal investigator.

Technical advice was provided by Dr. Sylvia R. Mayer, Air Force Task Scientist, Electronic Systems Division, and Lt Joseph J. Solga, Electronic Systems Division, Contract Monitor. The authors wish to express their appreciation for the encouragement and assistance provided by Lt. Col. H. W. Carter and Lt. Col. R. E. Hilliard, Headquarters, United States Air Force (AFXOX), Lt. Col. W. B. Malon, SAC Headquarters, March AFB, California, Capt. Eliot Weitz, Electronic Systems Division (ATC Training Cadre), Lt. Gerald Blais, Electronic Systems Division, R. W. Hall, System Development Corporation, Colorado Springs, Colorado.

This report has been reviewed and is approved.

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ABSTRACT

This document presents the findings of a research study on a computer-aided training subsystem for USAF command and control personnel. In this study, two major tasks were performed. The first was the identification of critical personnel functions in current and projected command and control systems and the applicability of advanced training strategies and methods for on-the-job training. The second was to determine the feasibility of applying these strategies and methods through a computer-directed training subsystem within the Electronic Systems Division (ESD) Command and Control Support Facility. The Computer-Directed Training Subsystem (CDTS), currently under development at SDC through Air Force contract F19628-67-C-0427, served as the basic system. Information was developed to determine the additional features and modifications that would enable CDTS to operate within the ESD environment and make use of the communicative capabilities of the AN/FYQ-45 graphics console.

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I. INTRODUCTION

The objectives of this study are to 1) determine the needs and requirements for on-the-job training support for personnel in present and future USAF command and control systems, and 2) determine the feasibility of implementing a modified Computer-Directed Training Subsystem (CDTS) in the Electronic Systems Division (ESD) Command and Control Support Facility*.

The first task involved determining the requirements for training of USAF command and control personnel. While it was necessary to survey the functions performed by these personnel within existing command and control systems, no attempt was made to identify system-specific training requirements. The objective of this survey was to identify and define typical personnel functions. At the same time, it was necessary to define them in sufficient detail so that implications and feasibility of using computer-aided training could be determined. Four representative systems were chosen and their personnel functions examined. The next step was to examine the future command and control systems. This was done and the results blended with the requirements found in current systems to predict the requirements for the future. A summary of personnel functions at the various levels was prepared and examined to determine the feasibility of employing various strategies and methods of computer-aided training. CDTS served as the basis for an experimental system at the ESD Command and Control Support Facility. New features and the modifications required in CDTS to permit interface with the AN/FYQ-45 graphics console at the ESD facility are identified.

The second task was an analysis of the recommended modifications to CDTS. It included:

- . A brief description of the design concepts for integration of CDTS into the Air Force Phase II Base Level System.
- . Modifications required for CDTS permitting the use of the AN/FYQ-45 (Q-45) as its primary I/O device. This task considered only those factors involved in replacing the teletypewriter with the Q-45, using the alphanumeric keyboard to enter data and displaying standard textual data outputs.
- . Modifications required to enable CDTS to operate in ESD's IBM 1401 computer. This task involved considering storage requirements for CDTS and the importance of quick response time in an instructional machine.
- . Modifications required to other programs to enable CDTS to operate in ESD's Command and Control Support Facility. This task was primarily concerned with intermediary facilities that would function between CDTS and the Q-45, such as the Computer Interface Buffer (CIB) and operating systems of third generation computers that carry out I/O operations.

* CDTS is currently being developed at SDC under Air Force Contract F19628-67-C-0427.

- . Expanding CDTS to provide additional command and control training capabilities and to fully utilize the interactive capabilities of the Q-45 for training purposes.
- . Alternative methods of operating CDTS, linked with the Q-45, in the ESD Command and Control Support Facility. The emphasis in this task centered around the relative advantages of locating CDTS in an external computer other than the IBM 1410.

II. COMMAND AND CONTROL SYSTEM DESCRIPTIONS

A brief study was made of four representative command and control systems. A major factor in choosing these systems was that each of their using commands was assessing the need for new ADP equipment as a subset of the World-Wide Military Command and Control System (WWMCCS). This assessment is considering the advantages of a "family" of new (third generation) computers and associated systems software to meet expanding data processing requirements and to support specific missions.

THE STRATEGIC AIR COMMAND CONTROL SYSTEM

System Description

The Strategic Air Command Control System (SACCS) supports CINCSAC, his staff, and subordinate commanders in their day-to-day job of monitoring, controlling, and planning SAC's complex, worldwide operations. The system automatically transmits, stores, processes, retrieves, and displays data such as missile and aircraft performance characteristics, readiness and disposition of forces, logistics, maintenance, weather, and enemy target descriptions. This is done to help SAC personnel to monitor their forces and resources, evaluate the impact of current operations on the ability to meet potential commitments, control existing plans and operations, and create and evaluate new plans.

System Configuration

SACCS has three equipment subsystems--Data Transmission, Data Processing, and Data Presentation--and four computer program subsystems--Executive, Control, Planning, and Utility.

The Data Transmission Subsystem has many remotely located message input and output centers at SAC bases, four computer-controlled message switching centers--one located at SAC Headquarters at Offutt Air Force Base near Omaha, Nebraska, the other located at the headquarters of SAC's three numbered Air Forces--and the communications links between message-switching centers and message input and output centers.

The Data Processing Subsystem consists of three AN/FSQ-31v computers* and peripheral equipment. Two of these computers, installed at SAC Headquarters at Offutt, are linked to the message-switching center there. The third computer, installed at 15th Air Force Headquarters at March Air Force Base near Riverside, California, is linked to the message-switching center located there. Operational responsibility can be assigned to any of the three computers.

*The AN/FSQ-31v computer has a core memory of 65 thousand words of 48 bits each, with a 2.5-microsecond cycle time. Auxiliary storage consists of 278 thousand words on high-speed drums, 13 million words on disks, and 11 or 12 tape drives.

The Data Display Subsystem has hardcopy printers and equipment for processing film and projecting wall-sized, group displays in seven colors. Similar display equipment is linked to message-switching centers located at SAC Headquarters and at the three SAC Air Force Headquarters.

System Operation

Messages originating at SAC bases are manually entered into the system with keyboard input devices, and are automatically encrypted and transmitted to the nearest message-switching center, where they are either relayed to their final destination or decrypted and sent to the appropriate computer for processing. The computer checks its input messages for plausibility and transmission errors and periodically updates the operating files stored on disk and drums. Input messages are also checked for critical events that might trigger special processing or a special display for staff action. Output messages are sent by the computer via the message-switching center to the Data Display Subsystem or to output terminals at SAC bases.

THE AIR FORCE INTEGRATED COMMAND AND CONTROL SYSTEM

System Description

The Air Force Integrated Command and Control System (AFICCS, formerly 473L), is a general-purpose, multiaccess data management system. It assists the Air Force Headquarters staff in their job of managing and controlling the worldwide resources of the U.S. Air Force--forces, material, bases, specialized personnel, communications, and command and control elements. The system works by maintaining files on such things as contingency plans, force status, exercise schedules, airfield facilities, and aircraft and missile performance characteristics by evaluating planning operations in terms of aircraft capability, available and operationally ready forces, effects on airbase facilities use of selected resources, and by monitoring aircraft movements during planned deployments. In this way it helps Air Staff officers to plan, monitor planned actions, and replan when necessary.

System Configuration

Prior to the installation of the ADEPT System, which operates in an IBM 360/50H computer, the interim operating system, located in the Pentagon, consisted of two IBM 1410s with four IBM 729 IV (Bunker Ramo BR-90) shared between the 1410s. One 1410 was used for developmental programming work. The other was used around the clock for the operational system.

System Operation

A large number of special-purpose operational programs have been written for the Hq USAF system to perform various computational and file-processing functions. A feature of the Hq USAF system is the way in which the operators communicate with the system to call for computation and to process files. The operator sits at a console containing a cathode-ray tube display, a typewriter keyboard, a fixed-function keyboard, light pen, hardware control keys, and a

variable-function keyboard. To call for the operation of a specific application program, he places a mechanically coded and visually labeled plastic overlay onto the variable-function keyboard. This loads the communication portion of the program into core memory.

The operator provides the program with parameter values via the typewriter keyboard and controls its operation by means of the function keys. (At any given stage, only the acceptable function keys are lighted.) The program's response--either computer results or cues for further operator action--are shown on the cathode-ray tube display.

Information requests are also introduced to the system with punched card decks. These are batch-processed to provide printed output.

NORAD COMBAT OPERATIONS CENTER SYSTEM

System Description

The mission of the NORAD Combat Center Operations System (NOCOPS) is to provide CINCNORAD and his staff with real-time information about the enemy aerospace threat and NORAD defense forces and operations. This gives CINCNORAD a basis for making decisions concerning the aerospace defense of North America. The information assists the Command in detection, threat evaluation, force monitoring, damage assessment, battle management, and reconstitution planning, enabling effective control over the Command's forces, weapons, and warning systems.

System Configuration

Employing a triplex configuration of Philco 2000-212 computers, the system shares central data processing equipment with the DELTA (496L) system and may drive BMEWS (474L) display panels.

While the NORAD COC program is running in one of the computers, accepting the COC's inputs and driving its 16 cathode-ray tube display consoles, DELTA is running in another computer. The third computer serves as backup for both systems and for running utility or support programs. No automatic switchover is provided. If either the NORAD COC or DELTA computer fails, the computer operators manually reinitiate the affected system in the backup machine. Continuity is provided by switching the active drum files to the newly active computer, and also by using backup data periodically recorded on magnetic tape.

System Operation

NORAD COC receives inputs from many remote systems, such as SAGE, BUIC, BMEWS, and SACCS. Input methods range from automatic high-speed data link to manual teletype. Data from these sources are sorted, stored, and made available to CINCNORAD and staff through a variety of displays and hard copy output. Selected alert information is automatically transferred to subordinate, lateral, and higher commands.

The operating program manages a constantly changing data base, performing straightforward input, storage, retrieval, and display functions. It does relatively little computation. The program also has a recording capability for use during live or simulated operations. The recording can be processed to produce a message description tape and a wide variety of historical and summary reports.

The system is required to update the data base rapidly so that displays requested by users will reflect current information. To permit rapid response to display requests, the data base organization is oriented toward display processing. The query language is quite rigid but allows considerable flexibility in building up displays. Using light pens and banks of switches, operators can take console light pen or switch actions to request or modify preprogrammed displays. Using a typewriter keyboard, they can take console keyboard actions to enter values into the data base.

For our purpose here the most significant features, as far as the system users and operators are concerned, have to do with response time--the generation and updating of multiple displays in a timely way. A unique priority-processing scheme employed by the program permits real-time data base maintenance and rapid response to queries from many consoles, even though the computer is not really designed for real-time, multiaccess, interactive operation. Even more important, the operators can control the scheduling parameters for displays; they can increase or decrease response time as well as console service time.

THE NORAD SPACE DEFENSE CENTER SYSTEM

System Description

The NORAD Space Defense Center System (DELTA) is a real-time system that assists Air Force analysts and operations personnel in processing satellite observations from a worldwide military and civilian network of optical and radar sensors. The system tracks, identifies, and displays space information about all man-made satellites. This information is used by CINCNORAD to evaluate enemy threats and for space defense decision making.

System Configuration

The DELTA program will run on any of three identical Philco 2000-212 computers installed in the Cheyenne Mountain Complex*. The NORAD COC program runs on a second Philco 2000-212, while the third serves as backup to the first two, running utility and support programs when it isn't down for maintenance. Switching the computers among the NORAD SDC, COC, and backup functions is done manually.

*Each Philco 2000-212 has a core memory of 32 thousand 48-bit words, with a cycle time of 1.5 microseconds. Auxiliary storage consists of magnetic tape and two magnetic drums containing over 500 thousand words.

The NORAD SDC computer is linked with a Burroughs D-825 computer, which performs message-switching functions--routing teletype traffic within the NORAD cavern. The D-825 relays teletyped satellite observations directly to the NORAD SDC computer and receives back messages for automatic transmission to the sensors. A Philco 1000 computer can be linked to the NORAD SDC, as an elaborate teletype paper-tape reader-punch, to provide an off-line backup for this function.

Other equipment attached to the NORAD SDC computer includes the operator's console typewriter, a user terminal consisting of a typewriter and a card reader* and a high-speed line printer.

The Delta program consists of a three-level modular collection of subprograms--executive subprograms, control subprograms, and function subprograms--that can be organized into a variety of processes. The executive subprograms control the execution of processes and perform all input/output. They also perform the processes of initiating and terminating system operation and recovering from equipment faults. Control subprograms invoke the execution of prespecified (and easily modified) sequences of function subprograms by passing to the Executive requests for input/output and for the operation of function subprograms. The function subprograms perform the basic data processing tasks.

System Operation

The DELTA program operates as follows: when observation inputs come in, the currently operating process is briefly interrupted so the Executive can store the observations in a buffer on one of the drums. Similarly, when a process request is entered from the operator's console or from the user's terminal, the current process is interrupted. If the newly requested process has higher priority, the core memory content for the current process is saved on drum and the new process is executed. Otherwise, the Executive merely places the new request in the process-request queue and resumes the current process. When a process is completed, the Executive selects from the queue, for execution, the process whose request has the highest priority, retrieving the appropriate subprogram either from tape or from drum.

The Executive itself will automatically queue (that is, place in the queue) requests for some processes on the occurrence of certain conditions. Observation input processing is automatically queued, for example, when enough observations are received or when enough time (such as two hours) has elapsed since the last observation input processing. The processing of tagged-unknown observations** is automatically queued whenever a set of such observations is received. All other process requests, however, are manually entered--some on a regular schedule--by the computer operator via the console typewriter and toggle switches, or by the duty analysts at the user's terminal. Still, most

*A modified keypunch can be attached also, as an on-line punch, but is ordinarily used off-line, for manual card punching.

**Tracking radars are assigned to track specific satellites. Whenever they track an unspecified space object, they generate a set of tagged-unknown observations.

user requests for the execution of control or function subprograms are pre-stored on magnetic tape (along with one or more sets of any necessary parameter or data cards)* and enter the system in batches. The computer operator first mounts a magnetic tape containing a batch of subprogram requests and then enters a request for the execution of the entire batch as a single, though not necessarily integrated, process. Other requests entered by the computer operator are primarily for executive processes.

The duty analyst at the user's terminal enters process requests for the execution of control or function subprograms through the terminal typewriter or card reader. Request formats, similar to those on the batched request tape, but limited to no more than twelve lines or cards, are identical in either case, and include parameter values needed by the process. At the terminal typewriter, the analyst is encouraged to enter his request without hesitation or error. A pause of more than 18 seconds between characters will lock the keyboard and automatically cancel the request. Typing errors can only be corrected by manually cancelling the request. Cancelled requests must be completely retyped.

Outputs generated by DELTA I processes are primarily stored on magnetic tape, for off-line printing by a Philco 1000 computer. Certain low-volume outputs, however, can be routed to the on-line printer. Outputs to the console and terminal typewriters consist largely of system status information and request-error messages. Finally, output messages destined for locations outside the NORAD complex are sent directly to the Burroughs D-825 computer for automatic teletype transmission.

*The subprogram is reexecuted for each set of parameter and data cards.

III. FUTURE COMMAND AND CONTROL SYSTEMS

In the previous section, representative existing command and control systems were described. As mentioned earlier, a major reason for including them in this study was that each of the using commands is contemplating replacement of the current ADP equipment with a subset of the WWMCCS family of computer systems.

The WWMCCS is an integrated network of separate systems. Each member system has an autonomous role in which it assists the commander or director and his staff in the performance of the operational tasks assigned to the command or agency. In addition, each member has a role in which it acts as an element of, and is responsive to, one or more larger systems. Both the autonomous and the systems roles are supported simultaneously by each member system.

In the autonomous role, each member of the WWMCCS performs data collection, storage, retrieval, manipulation, and distribution tasks for its own command or agency. The level of data maintained by each system is determined by the commander or director.

In the system role, each member system supports the requirements for data exchange imposed by the larger system or systems of which it is a member. For instance, the systems of component commands of the unified commands are members both of the systems of their unified command and their parent service and thus provide data interchange within both of these systems.

When we speak of future systems, we frequently use the phrase "third generation." There are attributes or characteristics of this new equipment, and its associated software, that are certain to influence future command and control systems. Some of these are:

1. The use of "Higher Level Programming Languages"
2. The trend toward multiprogramming and multiprocessing systems
3. Real-time input and output requirements
4. The use of remote consoles for interactive processing
5. The trend toward the use of real-time data management systems using flexible, general-purpose query languages
6. The use of "families" of computers to satisfy the computing requirements for varied system applications and requirements

These systems will probably consist, as do the present, of the personnel, facilities, equipment, communications and procedures that provide technical and operational support for command and control missions.

The role of man in future command and control systems will be similar to his role in current systems. He will perform functions:

- . that the machine cannot perform,
- . for which he is best suited, according to the system designer, and
- . that for some reason, either judgmental, ethical, or as a matter of conscience, we will not trust to a machine.

The major changes will be to facilities, equipment, and communications. The systems themselves will be designed to fulfill requirements very similar to those found in current systems, but with increased emphasis on precision, scope, and response time.

The design intent of most command and control systems in use today was to have a direct interface between command-level personnel and system hardware. To date, this relationship has not developed. The many peculiarities and intricacies of system operation have made it impractical for command personnel to become familiar enough with system specifics to effectively interface directly with it.

Because of this, a group of system specialists have evolved as intermediaries. These people have assumed the job of filtering and routing data between the command people and the system. However, as system interface technology advances and user-oriented languages are developed, direct communication between command-level personnel and the system machinery becomes more possible and practical.

The trend in systems currently being procured is toward using families of computers with requirements for increased precision, flexibility, interaction capability, and fast response time. Past experience and future projections indicate that personnel to man these systems will require more general-level training and much more function-oriented training than has normally been provided in the past.

The procurement of families of computers will result in a need to train more people for a given computer. One significant saving is expected to be in the training of operators, programmers, and maintenance personnel. Currently, when a man is transferred from one command center, equipped with IBM equipment, to another, which may have Univac equipment, it takes months to retrain him. This wider training need will undoubtedly generate the more favorable cost/effectiveness that is needed to support new training techniques.

One trend in computing systems is the increased interest being shown in the use of time-shared general-purpose data management systems to respond to those command and control requirements that call for fast retrieval of information.

An illustration of a system, with this capability, is the Advanced Development Prototype System (ADEPT) which will shortly be installed at the National Military Command System Support Center and in the Air Force Command Post--in

the Pentagon. These systems, NMCS and AFICCS, are integral components of the World-Wide Military Command and Control System (WWMCCS).

Time-shared general purpose data management systems are designed to accommodate the needs of many users. Many of these users are not professional programmers as a rule, and may be unsophisticated in the technology of computers. They often have large volumes of structured data to deal with (that is, data having meaningful associations), and they are required to manipulate these data to solve their problems.

The ADEPT system provides the user with data management capabilities on an interactive basis along with the capabilities needed to construct other data processing application programs to respond to their individual requirements.

The ADEPT system is not a command and control system in itself. Basically it is an open-ended framework for a system. In addition to providing a large set of information-processing tools, it may be used to facilitate the development of new operational programs or the use of programs already developed.

ADEPT SYSTEM COMPONENTS

The ADEPT system consists of three major components: a time-sharing Executive, a data management system, and a programmer package. Each of these components and the current equipment configuration is discussed below.

TIME-SHARING EXECUTIVE

The time-sharing component of ADEPT consists of two major pieces, one called the Basic Executive (BASEX), the other the Extended Executive (EXEX). BASEX contains elementary functions such as an input/output processor, a scheduler that permits the dynamic adjustment of priorities, an interrupt processor, and a basic sequencer. EXEX contains routines to interpret user commands, file-inventory routines, and various other aids for both programming and nonprogramming users. The Extended Executive is intended to be an "open-ended" module to permit expansion when necessary. ADEPT will permit multiple access to the computer through a variety of input/output devices, including typewriter keyboards, small tabular displays, and cathode-ray-tube graphic terminals.

DATA MANAGEMENT (TDMS)

The data management portion of the ADEPT system consists of a set of integrated programs designed to handle the most frequently performed data management tasks. Included in this set are programs that allow the user to describe the entries in a data base, load them into the machine, ask questions about them, perform calculations on them, have them presented for his analysis, obtain hardcopy reports, and update and maintain the data base. Several related capabilities are also being developed as part of the data management portion of ADEPT; these include a procedure for integrating the data management features with the computational capabilities of JOVIAL, and a means for reformatting existing data bases to TDMS format using the META5 language.

PROGRAMMER PACKAGE

For the professional programmer, a JOVIAL compiler, an F-level assembler, and a number of service programs (including editing and debugging routines) will be provided. For the novice programmer who may occasionally wish to use a computer to solve short, "one-shot" problems, a user-oriented interpreter (TINT) will be provided. In addition, an integrated system that will provide extensive support to programmers at all levels is being developed as part of this portion of ADEPT. This system will assist machine users in all of the programming processes, ranging from program composition, editing, execution, and testing through program documentation.

HARDWARE CONFIGURATION

The equipment included in the ADEPT system currently consists of an IBM System 360/50H computer with 262,000 bytes of core memory; three selector channels for transfer of data between the CPU and drum, disk, and tape storage; and a multiplexor channel for transfer of data to and from interactive terminals and other input/output equipment.

IV. PERSONNEL FUNCTIONS IN COMMAND AND CONTROL SYSTEMS

INTRODUCTION

In our definition, an initial distinction is made between operational functions and system support functions. That is, functions carried on in the operating system which contribute directly to the fulfillment of its mission, as distinguished from support functions carried on to keep the system operating, but not directly related to its primary mission. Both of these areas involve critical personnel functions and were included in our survey, but the functions associated with each area are qualitatively different. In the survey, then, personnel functions were considered under two broad groupings--operational and system support. Each of those, in turn, has its own functional divisions.

Operational Functions

Control: The control portion relates to the personnel, procedures, and equipment necessary to direct control of the system. It includes personnel functions that literally are man-machine interaction, always directly mission-related. With rare exceptions, the functions are bounded by man and machine, and are typified by console operations.

Command: The command portion has to do with planning and assessing, and the allocation, deployment, and commitment of resources. Although operational in the sense of being mission-related, the personnel functions are rarely machine bound. Inputs at the command level are more in the nature of second-order derivatives, summaries, and syntheses of control data, acquired by command personnel as a basis for decision making. They are typified by command and staff functions.

System Support Functions

System Hardware Maintenance: These are functions carried out by people that are directly related to maintaining system hardware, e.g. computers, communication equipment, display projectors.

System Software Maintenance: These are functions performed by people to maintain the operational readiness of the nonhardware portions of the system, e.g., computer programs, documentation, system procedures and personnel skills.

Taken together, these comprise what we chose to examine as "critical" functions: operational command, operational control, and system support. It is recognized that other essential functions exist in relation to the system. For example, finance, certain logistical functions, nonoperational status reporting, and liaison with other hierarchical levels. But these other functions are essentially administrative and peripheral to the operating system. No doubt, some would lend themselves to computer-aided training, but we do not include them in our definition of critical functions.

REPRESENTATIVE PERSONNEL FUNCTIONS

During the study, several representative personnel functions were examined in detail. As mentioned above, three areas were laid out: operational control, operational command, and system support. Sample functions in these areas are discussed below.

Operational Control

These functions are generally concerned with the "man-machine" relationship. The operational functions have to do with the acquisition of information (data sensing), processing of it (selecting, appraising, and evaluating), and responding to it (initiating some subsequent transformation or communication of the information).

Information is entered into the system through some means by man, e.g. typewriter keyboard, console push buttons, a light pen, sensor, decks of cards, reels of tape, or some other device.

Information is presented to man by the system through such devices as hard-copy printouts, CRT situation displays and tabular data displays, projected data on wall screens, and audible and visual alarm devices.

Actions are taken by personnel in these functions, almost always, based on procedures that define the nature of response the individual is required to make in any given situation. This is a significant criterion of control functions. "Procedures govern the human actions in control functions." These procedures, along with the operator's knowledge of program capabilities, system capabilities, input/output device operation, and organizational structure, are the key ingredients in virtually every personnel control function observed.

In the Air Force Integrated Command and Control System, the principal interface device is a Q-45 console. The following skills are required of the operators of the Q-45 console to fulfill the interface functions between the system hardware and the operational environment:

1. Operate the Q-45 console including use of fixed function keyboard and hardware control keys
2. Understand the mission of the AFICCS
3. Understand the terminology and nomenclature used throughout the system
4. Use primitives and modifiers that comprise the query language to interact with the AFICCS data base
5. Understand system output formats, how to vary them, and the meaning of any special symbols used
6. Familiarity with operational procedures that govern the requesting of data

7. Use of light pen to further define or control processing
8. Use of typewriter keyboard to communicate with the system
9. Understand data elements that form the data base, how derived, accuracy, where and how transmitted, file structure, etc.
10. Manipulate console overlays to control the variable function keyboard
11. Understand interface procedures with associated systems

In the Strategic Air Command Control System, the most widely used input device is the Remote Communications Central (RCC) which includes a Format Message Composer (FMC). The RCC/FMC combination is a message storage and transmission device which is used in conjunction with an input keyboard. It provides the operator with the capability of: (1) manual and semiautomatic composition of messages; (2) semiautomatic and automatic high-speed entry of messages into the system; (3) storage of preformatted, partially composed, and precomposed messages with search and edit capabilities; and (4) provision for guidance to the operator during the typing of messages.

Personnel skills relevant to this input function include the ability to:

1. Operate the RCC/FMC controls to enter data into the system
2. Understand the format and data content of the various system input messages
3. Understand the terminology and nomenclature used throughout the system
4. Insert system input data through the typewriter keyboard
5. Translate standard keyboard characters to produce unique system symbology
6. Understand the mission of SACCS and the operational procedures that govern the insertion of system data

Output from SACCS is in the form of displays. Presentation is on wall screens and/or printers. The wall screens are 16 by 16 feet square and show maps and digital data in seven colors. Impact printers, with 72-character line width, copy wall-screen digital data or are used independently.

Displays are "forced" by the system under certain conditions, but most are obtained through the Display Request Panel (DRP). The DRP has 15 columns of multipurpose pushbuttons. To request a display, the operator generally uses a handbook to guide him in preparing the request. This is due to the large number of requests, the variables that may be chosen to order the data in the request, and the fact that many requests must be entered in pieces requiring up to a maximum of some 50 passes over the keyboard.

Personnel skills relevant to this function include the ability to:

1. Understand the mission of SACCS and the operational procedures that dictate the actions to be taken for specified display outputs
2. Operate the Display Request Panel controls and understand its capabilities
3. Know the display request categories and the content variations available
4. Understand the content of the system data base
5. Understand the terminology and nomenclature used throughout the system
6. Translate unique system symbology into meaningful terms
7. Understand the meaning of the color codes in the wall displays

In the NORAD Space Defense Center System (DELTA), most functional operations are highly procedurized. A representative set of personnel functions are performed by the Duty Orbital Analyst. Two avenues of interaction are available for communication with the computer system: punched cards, which are batched onto tape for machine processing, or through an IBM 1050 terminal, which is, as previously discussed, a remote-access typewriter and a card reader. To perform his function the analyst must:

1. Be knowledgeable in celestial mechanics and astrodynamics
2. Be aware of the sensing elements and how they contribute to the mission of the Space Defense System
3. Know the functions and limitations of the computer programs available
4. Understand how to control and/or request the operation of computer functions and the insertion of data through the use of standardized card formats
5. Understand the overall mission of the Space Defense Center, sensing, cataloging, and summarizing data relating to satellites

Operational Command

Generally, command functions deal with a higher level of decision making than found in control functions and, as stated earlier, are somewhat removed from the actual man-machine relationship. Information used in the decision-making portion of command functions is obtained from other men who prepare or present summaries of machine-produced data, data from systems other than the command specific system, or additional data from related sources.

Decisions are made using the required data and orders for carrying out the results of these decisions are generally given to men who are engaged in or responsible for operational control functions. Decisions made at this level are more general in scope than at the control level and, probably due to infrequency and the considerable number of environmental-political considerations, do not lend themselves to procedural methods. "Policies are the major governing criteria for command functions."

In a NORAD Operation Center System, at the command function level, some typical personnel functions are to:

1. Establish the Defense Readiness condition
2. Establish the Alert Status for weapons
3. Establish the Air Defense Warning condition
4. Order the redeployment of weapons
5. Request and deploy augmentation forces
6. Order preplanned weapons dispersal and flush
7. Establish surveillance and tactical action reporting procedures
8. Order revisions in surveillance coverage
9. Order revisions in communications circuits, routing, and priorities
10. Request authorization and issue orders for the use of nuclear weapons
11. Order redeployment of material and personnel
12. Act on requests for authorization for special flights during emergency conditions
13. Order the implementation of various contingency plans in response to specific critical situations
14. Answer queries from higher and coordinate echelons concerning the threat and the aerospace defense posture

In the Strategic Air Command Control System, sample personnel functions at the command level are to:

1. Monitor actual versus planned status and capabilities of the SAC force in such areas as:
 - . Manned aircraft readiness
 - . Missile readiness

- . Weapons status
- . Pre- and post-strike base capabilities
- 2. Order revisions in force status to reflect changes in defense readiness conditions
- 3. Establish plans and subplans for effective application of SAC forces in emergency situations
- 4. Order redeployment of forces in response to critical situations
- 5. Monitor and control training missions
- 6. Plan and monitor positive control, authentication, and acknowledgement policies and procedures
- 7. Coordinate command data exchange with other agencies, e.g., JCS, USAF, NORAD, MATS

System Support Functions

Grouped here are personnel functions that contribute to keeping the system operating. Basically, two subdivisions are apparent: a) those concerned with system hardware, and b) those concerned with system software. Although these personnel functions are not directly related to the primary mission of a system, they must be carried out if the system is to be a success.

a) System Hardware Maintenance Functions

- . Interact with system users and operators to determine if system hardware is operating properly
- . Perform scheduled hardware maintenance tasks
- . Respond to unscheduled hardware maintenance requests
- . Replace or repair hardware elements found to be operating improperly
- . Provide assistance in training of operator personnel as required

b) System Software Maintenance Functions

- . Interact with system users to determine if system operation is satisfactory
- . Process problem reports
- . Recommend and evaluate system software design changes
- . Analyze, design, or redesign system software changes in response

to requested design changes or problem reports

- . Program, test, and install system software changes
- . Write or rewrite required system documentation
- . Assist in training of user personnel

System Software Skill Requirements: Most system software maintenance functions are done by people trained in system analysis and programming. To properly perform their functions they must have a complete understanding of the system they are working on, the programming language used, and the techniques and methods of implementing one into the other. The skills listed below are a composite of those applicable to all systems surveyed. Specifically, these people must be knowledgeable in:

1. The specific computer
2. The higher-level language used
3. The machine-level language used
4. The techniques of data organization
5. Data manipulation and retrieval methods and languages
6. The use of subroutines and interaction procedures
7. Program sequencing and timing
8. Storage allocation
9. Test and verification tools and procedures
10. Techniques for isolating, identifying and correcting errors
11. The organization of system elements to perform required functions
12. The characteristics, capabilities and limitations of related system equipment, such as sensor devices, display equipment, data transmission equipment, and any other equipment system used or controlled by the system
13. The organization of the using agencies
14. The operational requirements for the system
15. The policies and procedures of the using organization
16. Simulation tools, if any, used for training system users
17. The overall mission of the system and the using command

18. The procedures for processing the reports and documentation associated with system problems and changes
19. The structure, style, and requirements for the various levels of documents required to describe the system

SUMMARY OF PERSONNEL FUNCTIONS AND SKILLS

To evaluate the use of a computer-aided training system as a method of training personnel for command and control systems, it is useful to summarize the functions performed and the skills required in current systems. This is meaningful, as personnel functions for future command and control systems were determined to be similar even though these systems are projected to require new or modified tasks.

This summary is arranged according to the three general groupings of personnel functions in command-control systems mentioned earlier--operational control, operational command, and system support.

Operational Control

The following skills are representative in this group:

1. Understand the mission of the system
2. Understand system operation, system structure, boundaries, capabilities, and limitations
3. Understand terminology and nomenclature used throughout the system
4. Be familiar with operational procedures that govern the input, decision, and output responsibilities for their functions
5. Know the capabilities and limitations of the input/output equipment used to interact with the system
6. Know the policies and procedures that describe interface requirements with associated systems
7. Know system data base structure and content
8. Perceive and translate systems output displays into operational information
9. Know the format, content derivation, and error limits of system input data
10. Know the format, content variation, and significance of special characters or color coding of output displays
11. Where a data base management capability exists, understand primitives and modifiers used to construct queries

Operational Command

The following functions are representative of those required of personnel in this grouping:

1. Prepare policies and procedures for continuing operations under various degrees of system degradation
2. Coordinate requirements for interaction and data exchange with other echelons of command and with associated commands and agencies
3. Formulate, execute, and monitor policies and procedures that ensure effective system operation
4. Formulate, execute, and monitor policies and procedures that ensure effective system support
5. Understand the overall mission of the command and how the system contributes to its success
6. Monitor and evaluate system performance
7. Understand system operation, structure, boundaries, capabilities, and limitations
8. Execute operational policies based on available information
9. Order redeployment of resources in response to critical situations
10. Monitor and evaluate current operational status against planned status and performance

System Support

The following skills represent those required of personnel to perform the system software maintenance function:

1. Know the capabilities of the computer used
2. Understand the machine language and higher-level language used to program the system
3. Understand the techniques of data organization, storage allocation, and methods and languages used to manipulate and retrieve data
4. Know the organization of system elements, program sequencing, timing, and the use of subroutines and interaction procedures
5. Know the techniques for isolating, identifying, and correcting errors
6. Know the test and verification tools and procedures

7. Understand the overall mission of the system and the organization, operational requirements, and the policies and procedures of the using commands and agencies
8. Understand the characteristics, capabilities, and limitations of related system equipment
9. Understand the role and use of simulation tools for training
10. Know the procedures for reporting and processing problem or change reports
11. Understand structure, style, and requirements for system documentation

V. COMPUTER-AIDED TRAINING STRATEGIES AND METHODS

INTRODUCTION

The survey of several representative command and control systems, including future projections, indicate that certain personnel functions are required for an effective and efficient system operation.

The major task confronting the operation of command and control systems is manning the allocated manpower slots with personnel who have been sufficiently trained in the various specialized tasks and functions at the operational command, operational control, as well as the system support level.

Personnel assigned to a specific command and control system normally reflect a varied cross-section of military educational and background experiences. The task of the specific command is to provide these personnel with the necessary and sufficient information and skills in an optimized time period so as not to disrupt the continuity of system operation.

Within the Air Force, the two basic instructional methods used have been instruction in a classroom environment and on-the-job training. (This document is concerned with an innovative combination of these two, but with primary emphasis on the former.) This is due to the proposed operation of this subsystem within ESD's C/C Support Facility. In the event the subsystem becomes an integral part of WWMCCS, it would, in fact, be a vital on-the-job training tool at the operational command level.

This has included:

- . Formal classroom presentations
- . Text books
- . Hands-on training
- . Self-instructional texts
- . Simulation of system equipment and/or system operation
- . Observation of actual system operation
- . Use of various audio-visual equipment and techniques to include: movies, film strips, tape recordings, closed circuit television, vu-graphs, slides, etc.

These methods of instruction, for the most part, require personnel to present the material and monitor the progress of the class or individual.

This is not a difficult task when the instructor/student ratio is reasonable. However, as the ratio of students to instructors increases, the effectiveness of the instruction tends to decrease. The recognition of deficient areas and responses to individual needs by the instructor is limited.

The instructor/student ratio has in most situations become taxed. The demand for highly motivated and skilled personnel to command, control, and support

current large-scale command and control systems continues to increase. And, if future projections are correct, the trend will continue.

Selecting and training sufficient instructors is one approach to solving the problem; however, it has for the most part been difficult to achieve. The incorporation of audio-visual devices as instruments for presentation of instructional material does permit fewer instructors to communicate with increased numbers of students. However, this requires the material to be developed and presented at some predetermined rate to the "average" participant in the course. Again, the emphasis, for practical reasons, must be to instruct the greatest number in some optimized time period.

The instructor may attempt to perceive and attend to individual needs, weaknesses and/or requests for additional guidance. However, this is normally a "catch-as-catch-can" operation as the demands usually exceed the available time of the instructor.

Individuals who do not attain the necessary and sufficient information and skill sets to function effectively within the system may degrade the entire system operation. Any degradation or lowering of system performance can create additional problems for the individual. Under additional stress, the individual is even less prepared or capable of response. This in turn places an additional burden of responsibility and stress upon the personnel who must attempt to overcome the system degradation and return operation to the desired level of performance.

The instructional task is further compounded by at least two additional areas which require attention. One is the need for individuals to be given new information and skill sets to keep abreast of the expanding and increasing technology. Another is the requirement to perform assigned tasks under differing system conditions--the day-to-day system operation, and the system operation under a state of national emergency or stress; the latter condition generally being the primary mission and reason for the existence of the system. To exercise the system in these areas, simulation is used at various levels outside as well as within the command and control system. Thus, the need to provide to an increasing number of command and control personnel the information, skill, and experience to perform their assignment is a continuing requirement.

To meet these challenges and alleviate the situation to some degree, attention in recent years has been directed to the use of computers to complement already existing instructional techniques and methodologies. This was predictable since it was the development of computer technology, both in hardware and software, that made possible the existence of large-scale information processing command and control systems.

During this same period, the development and implementation of programmed instruction (PI) principles and techniques was occurring. PI is attempting, basically, to provide a Socratic instruction environment; that is, an ideal instructional situation. The student proceeds at his own pace, with the

instructor providing appropriate guidance and feedback. Since present day costs and manpower resources preclude a "pure" Socratic environment, the instructor in a PI environment is relegated to self-instructional material.

To many, the incorporation of many PI principles within a computer aided training system appeared feasible. Use of computer aided training systems would permit:

1. Individualized instruction
2. Self-pacing
3. Immediate feedback
4. Sophisticated decision-making and branching techniques
5. A tireless instructor
6. Standardization of instructional material
7. Repetition of instructional material although the sequence (path) through the material might vary among individuals taking the specific course
8. Record initiation, maintenance, and processing
9. Instructors to have additional time to prepare special materials for classroom presentation

Computer-aided training systems can be described in their operation as--reactive or nonreactive, and in their purpose as--general purpose or specialized.

- . Reactive--Information and events are presented to an individual. The training system and instructional material are linked. The instructional material is modified as a result of interpreting and processing the responses by the individual. The material is not fixed in content, being influenced by the actions of the individual.
- . Nonreactive--Information and events are presented to an individual. The training system operates under control of an operating system but is not an integral part. The instructional material is not modified as a result of the individual's responses. The sequence of instructional material may vary among individuals but the content remains fixed.
- . General-purpose computer aided training systems permit a variety of instructional courses to be constructed and presented. Modifications can be made to the instructional course material through the capabilities of the computer aided training system. However, modifications to the computer aided training system can be made independently of the instructional course material.

- . Specialized computer aided training systems present a particular course. The course is normally an integral part of the computer aided training system. Modifications affect both the course and the training system. In many cases, the training system operates with a special version of the operating system. Changes and/or modifications by a nonprogrammer or a unsophisticated user are difficult to effect and usually require some type of recompilation.

Reactive computer aided training systems, which are usually specialized, are more amenable to presenting information and structuring events at the command level. As previously indicated, the command level requires a higher order of cognitive activity and is less procedurized. Command personnel must react to changing situations caused by events within as well as outside their immediate control but which affect their sphere of operation.

Situations can be presented with subsequent events and actions being modified as a result of the individual's response.

Nonreactive computer aided training systems, which are usually general-purpose, are excellent vehicles for presenting instructional material or situations which control and support levels where direct man-machine interaction is required.

Instructional material can be developed and presented to provide general system background information. The material describing the techniques and methods to manipulate system devices for data acquisition, processing and responding to system situations can also be developed.

A nonreactive computer-aided training system is more amenable for use within a developmental or experimental environment where the presentation and/or structuring of differing training situations is desirable. Creation of, or modifications to, desired training situations can be effected independently of the operation system.

Whether a computer aided training system employs a reactive or nonreactive method of presenting instructional material, the training of personnel in highly performance-oriented skills (e.g., loading a tape, processing a card deck, etc.) is difficult to achieve.

Emphasis during the initial development of computer aided training systems was placed at the cognitive level (intellectual activities) rather than the affective (attitudes and opinions) or performance (skill attainment) levels.

This emphasis was natural for several reasons:

1. PI principles and techniques, which were developed at the cognitive level, had an influence.
2. Measurement standards and techniques are more refined at this level, thus enabling a more precise assessment of the computer aided training system. This was also true for evaluating course material.

3. Instructional material was more readily available for conversion to a computer format.
4. The specification for various computer aided training systems were oriented toward the construction and presentation of instructional material at the cognitive level.

The performance and affective levels are now receiving some attention, although the primary emphasis still resides at the cognitive level.

Prior to indicating desirable specifications for a computer aided training system, those personnel functions and skills previously summarized under operational control, operational command, and support were examined. The intent of the examination was to determine whether these personnel functions and skills were adaptable to computer aided training strategies and methods.

However, it should not be construed, when a particular personnel function or skill is considered amenable to computer aided training, that the strategy, method, or approach is all-inclusive or exhaustive. Rather, it should be viewed as a suggestion or possible approach for the instruction of the personnel function through the use of a computer aided training system.

OPERATIONAL CONTROL

Personnel functions and skills at this level are primarily man-machine related. An operator is required to interface with a system device--usually a console. The operator must master the necessary information and attain the desired skills to perform his assigned task. The actions required are highly procedurized and mission-related. A mixture of verbal- and performance-oriented skills are usually required.

This level is the most adaptable to computer aided training systems. Instructional material can be presented at the operating console for maximum training benefit or at remote devices. "Hands on" training at the console can serve as a complement to instructional material presented via a computer aided training system.

1. Understand the mission of the system

A course can be constructed with a computer aided training system and presented to operators on-line at an operating console or at a remote terminal. The use of slides, film strips, or films may be used to complement the presentation. A level of understanding can be demonstrated by having the operator take a posttest on the presented material.

2. Understand system operation, system structure, boundaries, capabilities and limitations.

Again, this information can be presented as course material. System boundaries, if geographical, can be presented via slides with accompanying information--questions output on a CRT.

System structure, capabilities, and limitations can be described and in many instances illustrated using the output devices of the system. A description of the system operation can be presented or simulated which elicits the same responses as required for system operation. Hypothetical situations can also be presented which indicate how the system might function under varying conditions. The operator responds to queries and situations by using the devices available within the system, (e.g., light pens, alphanumeric keyboard insertions, switches, keys. In certain cases the use of "hands on" techniques may be more appropriate. It is the responsibility of the course designer to be thoroughly familiar with the capabilities of the computer aided training system and determine when the training requirements are better suited to a different instructional technique.

3. Understand terminology and nomenclature used throughout the system.

This information can also be presented as course material. The course, if properly designed, indicates with appropriate feedback whether the response is correct or incorrect. Slides depicting the equipment, terminology, and nomenclature used within the system can be developed and presented which instruct as well as test the individual's knowledge of the subject. The operator responds by using a light pen, cursor, keying device, or other available system equipment.

4. Be familiar with operational procedures that govern the input, decision, and output responsibilities for their functions.

The operational procedures can be presented as course material on the system output devices, (e.g., a remote terminal device, CRT, slides. Once a basic understanding of the operational procedures has been attained by the individual, situations or events can be designed and presented via the computer aided training system. Responses to the situations presented show the individual's understanding of the operating procedures, his ability to transfer information gained from one situation to another, and whether his actions are within the context of his assignment and responsibility.

5. Know the capabilities and limitations of the input/output equipment used to interact with the system.

A description of the input/output equipment capabilities and limitations can be presented by a computer aided training system. The course material can also be augmented with slides, films, paper aids, and video tape. Depending upon the assignment of the individual, exposure to different levels of descriptive material can be controlled also by the computer aided training system via key questions and corresponding branching instructions.

Performance-oriented skills may be stressed by requiring the operator to use the facilities available at the console in responding to questions, events, or situations presented by the computer aided training system. The computer aided training system processes the response, indicates the

appropriate feedback, and initiates the programmed action based upon the response. If the operator is at a remote terminal device, responses required at the operating console can be simulated by establishing conventions which the computer aided training program interprets as correct responses.

If the computer aided training system is reactive, responses are interpreted in all probability by the training system. However, if the training system is nonreactive, the interpretation and subsequent responses must be provided by the course designer within the body of the course.

6. Know the policies and procedures that describe interface requirements with associated systems.

These policies and procedures can be presented as course material. Events and situations can be developed and presented which test acquired knowledge of these policies and procedures. The computer aided training system could also be used to determine the adequacy or inadequacy of existing policies and procedures to cope with the situations presented. A visit to an interfacing system, if appropriate, may also be beneficial.

7. Know system data base structure and content.

The computer aided computer training system can be used to indicate and describe the kinds of data the particular system stores and processes. Slides and other visual aides may be appropriate to accompany the CRT or hardcopy presentation of the course material. Examples of data base content can be simulated by the computer aided training system and queries made of the operator to determine the depth of his knowledge.

Exercises can be generated by the training system which require the operator to input and extract data from a system data base using the keys, switches, cursors, buttons, etc., available at the training device. If the system data base is not accessible for instructional purposes, a pseudo base can be maintained within the body of the course or the computer aided training system can access, as required, the pseudo data base.

8. Perceive and translate system output displays into operational information.

A computer aided system can be used to present a variety of system displays which require operator interpretation. The specific structure and content of system displays can also be presented by the computer aided training system. Subsequent operator action, required by the display, is entered by using the various system input devices (e.g., light pens, alphanumeric keyboards, switches, keys). The computer aided training system interprets the response and outputs the appropriate feedback.

9. Know the format, content derivation, and error limits of system input data.

The format, content derivation, and error limits of input data can be presented as course material by a computer aided training system. The formats used within the particular command and control system can be

displayed on a CRT or slide projector. Questions concerning the legality of information or the particular placement of data within a display or system table can be generated. Error limits can be presented in an academic manner or the computer aided training system can be used to depict situations which will cause errors to be illustrated. The derivation of data content can be demonstrated using slides and/or off-line media as concomitant material to information displayed on the CRT by the computer-aided training system.

10. Know the format, content variation and significance of special characters or color coding of output displays.

System output displays can be presented by the computer-aided training system on the CRT. Color coding, if required in output displays, can be illustrated by using a slide facility, color television, etc. Output displays can be combined with input actions and displays. Displays can be simulated by the computer-aided system and the operator's response interpreted with the appropriate predefined display output. The use and legality of special characters can be presented by the computer aided training system with appropriate feedback being output based upon the operator's response.

11. Where a data base management capability exists, understand primitives and modifiers used to construct queries.

A computer aided training system can be used to impart the definitions and legal uses of system primitives and procedures to modify and/or construct queries. A course can also be constructed which permits the operator to simulate the construction of input queries. At each step in the input process, the training system outputs the appropriate feedback (message, display, etc.), as programmed by the course designer, to the operator. The operator interacts with the course in the same manner as with the operating system. The system operator can verify actions and procedures learned when interaction with the operating system is possible. The operator can also be given practice in construction and interpreting queries, which occur frequently or infrequently depending upon the instructional objective. Courses can also be developed which enable operators to gain experience in query construction which may be possible only under stress conditions or are restricted for security reasons. In the latter case, dummy information can be inserted into the course which permits query construction practice but does not violate security restrictions.

OPERATIONAL COMMAND

Personnel functions and skills at this level are not necessarily man-machine related. Personnel operating at the command level are usually required to take action and make decisions on information already summarized or synthesized at some lower level within the system. A high mixture of cognitive and affective interplay is required with a minimum emphasis upon performance-oriented skills. The use of computer-aided training systems at this level is desirable and possible but requires considerable effort and ingenuity to achieve.

1. Prepare policies and procedures for continuing operations under various degrees of system degradation.

The use of computer-aided training techniques is very difficult as the development and preparation of policies and procedures usually evolve out of given situations or requirements.

Instruction in the policies and procedures already derived can be prepared and presented. The use of a computer aided training system can be used, however, to show situations and events which point out the need for policies and procedures. Testing of existing policies and procedures can be accomplished by subjecting the system to various stress situations which require decisions and actions on the part of command personnel. The use of a reactive type training system is probably better suited to meet these instructional requirements. A dynamic training environment can be established which permits the execution of policies and procedures. The appropriateness of policies and procedures implemented during the instructional session can be assessed by examining the status of the system at the conclusion of the instructional session.

2. Coordinate requirements for interaction and data exchange with other echelons of command and with associated commands and agencies.

The actual coordination is best accomplished in a real-time environment. However, determining those data that should be exchanged with other commands can be assisted by computer aided training courses. Simulated situations can be constructed and presented on a CRT with slides and other visual devices as secondary sources of information. Command personnel can make responses and test alternatives. The type of data used in particular situations within the simulated environment could be tested for validity within the actual system environment. Depending upon the actions initiated by command personnel, the training system could output the results of the action taken, as well as what action should be taken if deviations occurred. If alternatives in action are possible, these could be indicated either automatically by the training system or upon request using a system device (e.g., light pen, switch, or key). The latter would probably occur only if provided by the course designer within the body of the instructional material.

3. Formulate, execute, and monitor policies and procedures that ensure effective system operation and system support.

A computer aided training system can be used to establish simulated situations and events which permit command personnel to formulate, and then put into execution, derived policies and procedures. Policies and procedures can then be subjected to execution within the actual system operation to determine their validity. Modifications to policies and procedures can be tested by constructing various simulated events using the computer aided training system.

4. Understand the overall mission of the command and how the system contributes to its success.

This is adaptable to computer aided training by constructing an appropriate course. The course can be presented on a CRT or hardcopy device. The use of other devices, wall boards, slides, vu-graphs, etc., to complement the course material is possible.

5. Monitor and evaluate system performance.

The ability to properly monitor and evaluate system performance requires experience within the system under varying conditions. Experience does not readily lend itself to instructional techniques. However, a computer aided training system can be used to present simulated system situation. Slides can depict situations and the training system used to present information as well as questions to the command personnel. Command personnel using the available system devices enter responses which the training system evaluates as correct or incorrect, outputting the appropriate feedback.

6. Understand system operation, structure, boundaries, capabilities, and limitations.

The type of information concerning the structure, boundaries, operation, capabilities and limitations of a command and control system can be constructed as a course and presented by a computer aided training system on a system device. Questions and course sequencing can determine the depth of understanding of the material by the participant and the need for remedial or follow-on instructional sessions. Again, system operation can be simulated in a static mode using display devices or dynamically by operating all or part of the system in a simulated environment. Those system components not actively involved can be simulated.

7. Execute operational policies based on available information.

A computer aided training system can be used to present predetermined information to command personnel. The situations presented can be completely independent with the interest focused upon the particular action initiated or chained in which the concern is on the cumulative action. Responses and decisions on the part of command personnel are entered using the apparatus available within the operating system, and the computer aided training system evaluates the response. A reactive type of training system is somewhat more amenable to presenting and responding to the instructional requirements comprising this type of personnel function than a nonreactive training system.

8. Order redeployment of resources in response to critical situations.

A reactive type of computer aided training system could be used to present simulated critical situations. The command personnel could enter into the system's data base the simulated redeployment of resources, or key in a specified response which the computer aided training system would interpret

as redeployment and respond accordingly. Special conventions can be established by which a specific switch, light pen, cursor, etc., can be used separately or in combination to represent a simulated input.

9. Monitor and evaluate current operational status against planned status and performance.

A computer aided training system can be used to present the planned status of a system for information purposes or to compare against a current conditional state. Comparisons between the current and planned status could be used to access areas needing attention for effective system operation. System performance under various conditions can be presented to determine how the system might perform. The computer aided training system can present queries to the command personnel concerning system performance. Several alternatives can be presented to command personnel with responses being initiated by use of a light pen or keying device.

OPERATIONAL SUPPORT

Personnel functions and skills at this level interface with the hardware and software elements of the system. Personnel operating at this level are usually either hardware or software oriented. Hardware maintenance requires a high degree of motor or performance ability. Software maintenance requires a mix of verbal and performance oriented skills. The use of computer aided training for some performance related skills can be difficult to achieve.

The procedures and steps within a particular performance skill set can be presented but it is recommended this information be completed with "hands on" experience.

1. Know the capabilities of the computer used.

The capabilities of the system computer or computers can be presented by a course. This type of instructional material usually elicits verbal skills as opposed to performance-oriented skills. The course can be presented at a remote terminal device where responses are entered using the terminal facilities. The course can be complemented with direct observation of the computer in operation under varying conditions and with "hands on" training.

2. Understand the machine language and higher-level language used to program the system.

The machine and higher-level language can be presented as a course by a computer aided training system. Apart from presenting the material necessary to describe the programming languages, exercises which require support personnel to construct program subroutines can also be required. The checkout of constructed subroutines can be done within the confines of the course, if provided by the course designer, or the computer aided training system can branch to another program which controls the construction and checkout of the subroutines. The support personnel could construct a particular program subroutine on line by using the proper

programming terms, conventions, formats, etc. Upon completion of the subroutine construction task, control can be returned to the computer aided training system and presentation of the course continued.

3. Understand the techniques of data organization, storage allocation, and the methods and languages used to manipulate and retrieve data.

The information concerning the organization and storage allocation of data contained within the system can be given as a course. Practice and experience in use of the conventions, primitives, and devices to manipulate and retrieve these data can be done with a reactive computer aided training system using the system data base or accessing a special data base constructed and maintained for training purposes. A nonreactive type of computer aided training system could be used in which support personnel use the various system devices--light pen, cursor, alphanumeric keying devices--to simulate the entering of queries for manipulating and retrieving data. The training system interprets the response and outputs the appropriate feedback (message, display, etc.).

4. Know the organization of system elements, program sequencing, timing, and the use of subroutines and interaction procedures.

The organization of system elements, how the operation of the program is sequenced, and the timing parameters can be given as a course. The support personnel are required to answer questions using the appropriate switches, keys, etc., at the system device or remote terminal. The recommended uses of subroutines and procedures for interaction can also be spelled out via course material. Situations and exercises can be constructed and presented by the training system with the support personnel entering responses via switches, light pen, keys, etc., for interpretation and processing by the training system. Verbal and lower level performance-oriented skills should be complemented by direct use of system subroutines under operating conditions.

5. Know the techniques for isolating, identifying, and correcting errors.

A reactive type of computer aided training system can be used to present situations which allow error detection and correction. The recommended procedures and techniques can be given via a nonreactive computer aided training system as a course. Actual trouble shooting experience, using the system equipment, should be used to complement other types of training.

6. Know the test and verification tools and procedures.

Use of the test and verification tools and procedures can be presented as a course. Exercises can be constructed and presented on a CRT or other display devices which require the support personnel to indicate the appropriate procedure and tool to use. Actual use of the system test and verification tools should be part of the training program.

7. Understand the overall mission of the system and the organization, the operational requirements, and the policies and procedures of the using commands and agencies.

Information concerning the mission of the system, the organization and operational requirements, and the policies and procedures can be translated into course material and presented. If support personnel must react to various system conditions, simulated situations can be presented by the computer aided training system on a CRT or slide projector and responses entered by using available switches, keys, buttons, etc.

8. Understand the characteristics, capabilities, and limitations of related system equipment.

The characteristics, capabilities, and limitations of related system equipment can be presented as course material to support personnel. Direct observation and "hands on" training should be used to complement the academic presentation of material.

9. Understand the role and use of simulation tools for training.

The role and use of simulation tools to train support personnel can be indicated within a course which is presented by a computer aided training system. The computer aided training system could be constructed to enable the support personnel to branch to the simulation tool (program) for direct experience. After a predetermined time period or error rate, the simulation tool could release control to the computer aided training system for remedial material or continuation of the course.

10. Know the procedures for reporting and processing problem or change reports.

The procedures required for reporting and processing problem or change reports can obviously be presented by a computer aided training system as course material. Representative problems and change reports can be presented via a slide projector, film strip, etc., with queries being presented by the computer aided training system on a CRT or hardcopy output. The support personnel respond by using the equipment available on the training device.

11. Understand structure, style, and requirements for system documentation.

The specifications and requirements for system documentation can be given as a course. Sample system documentation can be presented via slides and questions asked on the CRT or other output device. However, a practicum, in which documents are prepared by support personnel, may be needed in addition to academic training sessions.

COMPUTER AIDED TRAINING DEVELOPMENTAL AREAS

It must be emphasized that computer aided training is still in the developmental stage. Efforts should be continued to further develop the following areas:

- . A higher level of interrogative activity on the part of the participant interacting with the course material.
- . A more "natural" communicative language for all system users
- . More meaningful record processing
- . Diagnostic recommendations based upon past performance
- . Reliable predictors of success and failure based upon student histories

Concomitant improvements in hardware and software are needed to enhance data input/output processing to reduce cost factors. Computer aided training should be considered a complement to existing instructional methods--assuming an appropriate position within the body of instructional technologies/methodologies and not as a replacement or panacea for current or future instructional problem areas.

VI. INSTRUCTION OF PERSONNEL AT THE ESD COMMAND AND CONTROL SUPPORT FACILITY

GENERAL INSTRUCTIONAL REQUIREMENTS

The type of computer-aided training system to specify, develop, and implement depends to a large extent upon the intended uses of the system. In a developmental or experimental facility, the type of computer-aided training system employed should permit as many different experimental situations as possible within the confines of the hardware/software environment.

A highly sophisticated, general-purpose, computer-aided training system should be developed as opposed to a special purpose or one in which the instructional material is an integral part of the computer-aided training system. The latter normally requires an operational computer communication console which is used by the computer-aided training system to present instructional material and accept response inputs. This type of computer-aided training system reduces the versatility of an experimental facility in that modifications affect the course as well as the computer-aided training system, which increases the cost and manpower requirements.

In contrast, a general-purpose, computer-aided instructional system permits the presentation of various courses and instructional situations which can be evaluated for application in command and control systems.

Since the physical hardware of command and control systems varies, the device or instrument used in conjunction with the training system should permit an individual to manipulate apparatus similar to that contained within his parent organization. The device or instrument should enable the computer-aided training system to present a varied presentation of material and allow the individual to initiate alternative methods of response. This instructional device should have most of the following characteristics to meet the instructional requirements indicated for the personnel functions and skills comprising the command and control systems:

1. A CRT upon which course material is presented and responses may be entered
2. An alphanumeric keyboard used to construct and enter responses
3. A hardcopy device upon which to present course material
4. Light pen or gun to request displays, information and/or enter responses
5. A cursor for graphic input construction
6. A link between the computer-aided training system and closed circuit television for course presentation

7. A slide projector for presenting course material
8. A film projector for showing course material
9. A variable switch facility to request/construct information/displays and/or enter responses
10. A fixed switch/button/key facility to request/construct information/displays and/or enter responses
11. Various alarms, (e.g., audio, visual) as cues to changing environmental situations

AN/FYQ-45 GRAPHICS DISPLAY CONSOLE

The ESD Command and Control Support Facility has the same system configuration as an operational AFICCS installation. This configuration includes a Q-45 display console.

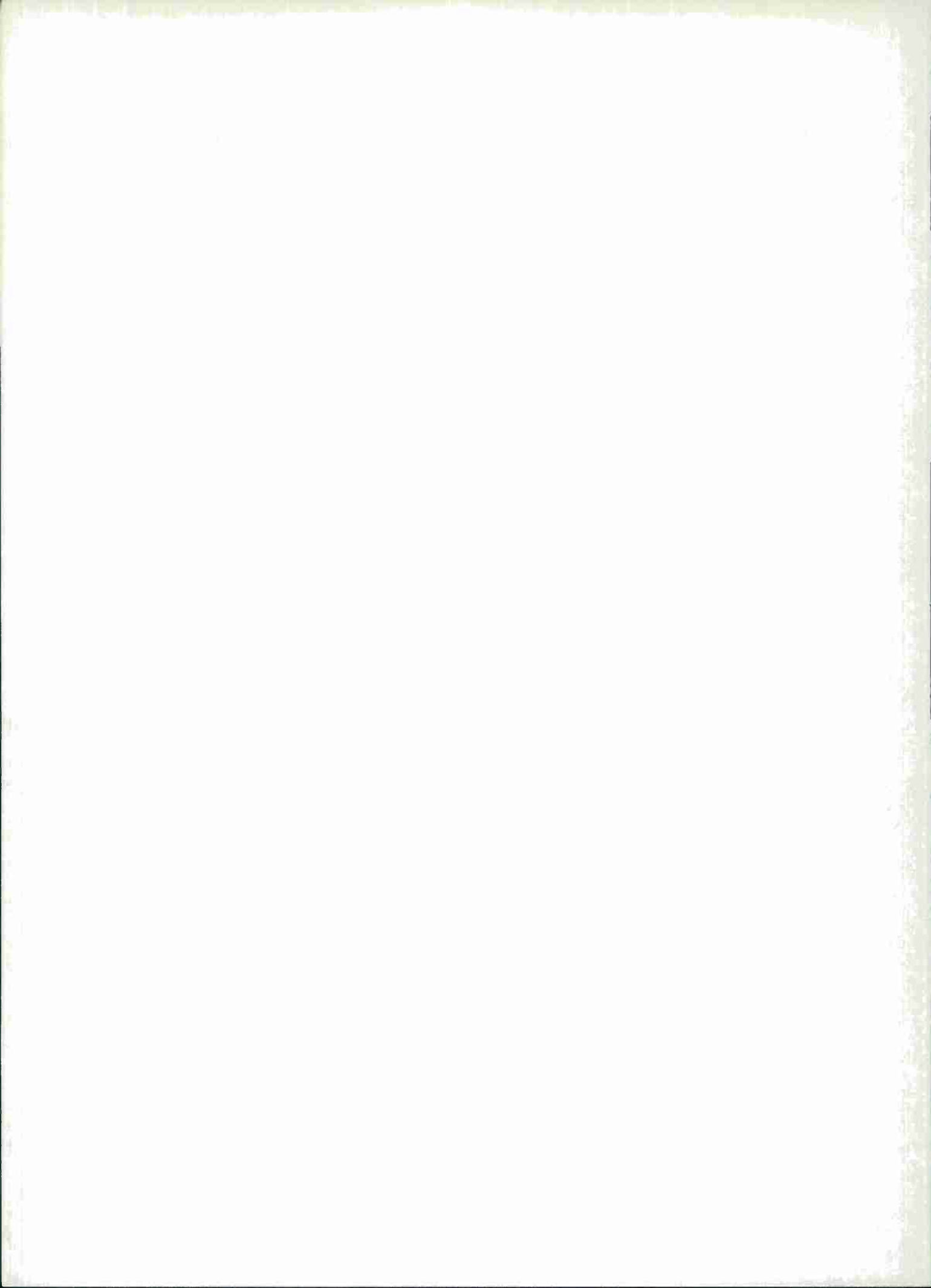
The Q-45 display console presents visual information on a CRT screen and provides controls for on-line and off-line manipulation of the information displayed. The basic console features are:

1. Electronic display. Alphanumeric symbols, special symbols, vectors, circles, and plotting points are displayed on the CRT screen in response to digital data received from an external system or generated internally by an operator using the console controls.
2. Projection display. Film transparencies are rear projected onto the phosphor surface of the CRT screen. The projected data can be displayed simultaneously with the electronic display to a viewer.
3. External communications. The console contains provisions for digital communication with an external system such as a digital computer, either directly or via a communication link.
4. Operational controls. The console provides operator controls to originate digital communication to an external system. Operator controls for off-line generation and manipulation of electronic and projection displays are provided. The operational controls include: a) variable-function keyboard, b) console-control keyboard, c) alphanumeric keyboard, d) light gun, e) cursor ball control, and f) status lights.

APPLICABILITY OF THE AN/FYQ-45 AS A TEACHING DEVICE

Comparison of the Q-45 display console characteristics with the instructional requirements indicates that the Q-45 has many of the characteristics required for this type of instruction. If the Q-45 is linked with a computer containing a computer-aided training system, it should prove to be an adequate teaching device. Various course material and instructional situations can be presented using the CRT and slide projector for textual as well as graphic displays.

Responses can be entered by using the alphanumeric keyboard, light gun, variable function keyboard and cursor control.



VII. COMPUTER-DIRECTED TRAINING SUBSYSTEM

DESCRIPTION

INTRODUCTION

The Computer-Directed Training Subsystem (CDTS) will serve as the foundation upon which the requirements to provide a computer-aided training system for the ESD Command and Control Support Facility will be assessed. This system is currently being developed at System Development Corporation under Air Force Contract F19628-67-C-0427 to provide a means of presenting instructional material via a computer for the Phase II Base Level System.

CDTS is a general-purpose computerized training system employing a user-oriented language. This computer-aided training system operates in four basic modes: lesson building, editing, execution, and record processing. The functions and capabilities of each mode of operation are defined as follows:

Lesson Building Mode

Lesson building mode permits a real-time construction of selected course material by a course designer familiar with the training system language and special conventions contained therein.

The course designer can commence to build a lesson or retrieve an existing lesson and continue to insert content material. Selected material is inserted and processed by the training program as "frame" units. Each frame is further segmented into groups and these groups are composed of individual lines of information. There are four different types of groups which may or may not be contained within any given frame. Group 1 contains the basic information used by the computer-aided training system to identify and locate the frame within the lesson. Group 2 is used to insert textual material to inform, require a response, or establish decision statements. Group 3 is used to specify anticipated answers, and Group 4 contains the actions to execute based upon the entered response. A lesson is, therefore, a series of frames sequenced as desired by the course designer.

The lesson building mode provides frame type selection by the course designer to meet the varying needs of course construction. The selectable frame types are:

1. Question frame--normally used to present course content material to inform or require a constructed response.
2. Multiple-choice frame--normally used to present course content material and alternate answer-choices for selection.
3. Decision frame--normally used to establish conditional statements which are executed depending upon a response to one or more frames.
4. Copy frame--a lesson building aid rather than a different frame type which instructs the program to copy any previously built frame.

Each selected frame is automatically numbered sequentially by the program.

The lesson building mode provides on-line assistance to the course designer after the selection of a frame type. The assistance is in the form of output messages which inform the course designer of the type of information to enter within each group of the frame (e.g., label frame, insert textual material, specify answers, and actions to institute based upon the processed response).

The lesson building mode provides a facility for on-line checkout and quality control of constructed material by the course designer. The course designer may enter the lesson execution mode from the lesson building mode and have his completed lesson material presented as though he were in a trainee status.

A record is maintained of his responses and sequence through the lesson frames. In this role, the course designer performs quality control on the lesson logic and material presentation. Full training-system privileges are available to the course designer in this mode, whereas, a trainee is confined to the parameters of the lesson.

The lesson building mode enables the course designer to preserve completed course material onto an appropriate peripheral component. The program requests an identification from the course designer. If the identification is legal the program associates the identification with the lesson affording a measure of protection against unauthorized changes or uses.

The lesson building mode permits the linking of two or more lessons to form a course of instruction.

Lesson Editing Mode

The lesson editing mode permits on-line printout of any portion of any constructed course for visual quality control. To avoid system degradation due to excessive input/output operations, only a single frame per request is printed on-line. However, the entire lesson or selected portions can be printed off-line.

The lesson editing mode enables the on-line modification of course material by the course designer.

Insertion. The training system determines the level of insertion desired; frame, group, or line, and whether the insertion is to occur within existing material or be added to the lesson material. If a single line is specified, the program prints out the requested line for easy reference and changes are entered. The new line of information replaces the old line in the lesson.

Deletion. The training system determines the level of deletion desired; frames, groups within frames, or lines within groups, and removes the material from the lesson.

Lesson Execution Mode

The lesson execution mode permits the retrieval of a lesson by the course designer or trainee. The program requests whether the user is a trainee and requires an inserted identification which is compared against the identification associated with the lesson. The results of the identification comparison dictate whether the program treats the user as a course designer with full program capabilities or a trainee confined to the parameters of the lesson.

When the user is a trainee, the program positions the lesson to the proper frame depending upon whether the trainee is starting or continuing the lesson.

The course designer can execute the lesson from any legal frame and has complete freedom to traverse the frames within the lesson.

Lesson execution mode allows the trainee control over the presentation rate of course material, subject to the constraints of the operating system and the course designer's intent.

Lesson execution mode contains service functions (PHONETIC comparison, KEYWORD match, or ORDER permutation) for evaluating inserted answers which depart from anticipated responses as programmed by the course designer. These service functions operate at the course designer's discretion.

PHONETIC Service Function. PHONETIC causes all words in both the course designer's answers and the trainee's responses to be encoded by the training program and the encoded messages compared for a possible match. This permits the misspelling of words by the trainee. If a misspelled word is within the encoding criteria, the response is considered correct by the program.

KEYWORD Service Function. KEYWORD causes the program to disregard everything in the trainee's response except that which the course designer has specified to be matched.

Extraneous information may be included as part of the response without penalty. When this service function is inoperative, the program makes an exact character-for-character comparison to determine if the trainee's response matches the course designer's answer.

ORDER Service Function. ORDER causes the program to ensure that the words specified by the course designer appear somewhere in the trainee's constructed response--independent of order. When this service function is inoperative, the program treats the trainee's response as a standard English statement. The words in the response must be in the same order as specified by the course designer.

The lesson execution mode performs automatic evaluation of trainee responses. Inserted answers and lesson-specified answers are evaluated for possible matches.

Lesson execution mode outputs immediate feedback to the trainee at the end of his response. Based upon the answer-matching process, the program selects the appropriate type of feedback/action:

1. Feedback--enables the course designer to specify appropriate messages based upon trainee response. If no message is specified, the program randomly chooses one from a table containing positive and negative comments. After printing the message, the program branches to the next frame in sequence or follows a subsequent command.
2. Repeat--permits the course designer to specify a feedback message requiring another response. If none is specified, the program prints "WRONG TRY AGAIN" and waits for another response.
3. Correct--instructs the program to print "THE CORRECT ANSWER IS:" followed by the answer indicated as correct by the course designer.
4. Branch--permits the interruption in course sequence. The program can be instructed to branch to another frame or a different lesson.

Lesson execution mode detects illegal actions by the trainee and initiates appropriate recovery cycles.

Lesson execution mode dynamically sequences the course material as a result of trainee responses and the design of the course.

Lesson execution mode permits the continuation of a lesson at an appropriate entry point after a lesson interruption.

Lesson execution mode permits on-line establishment and maintenance of trainee performance records. The program updates the trainee's record after presenting each frame and evaluating the inserted response.

The program preserves the trainee's record upon completion of the lesson or when the command to terminate the training session is inserted. The trainee can discontinue a training session and continue from the proper point in the lesson at a subsequent session.

Lesson execution mode enables a review of lesson material by inserting an appropriate command. After the review session, the lesson can be continued from the frame prior to requesting the review or another review session can be elected.

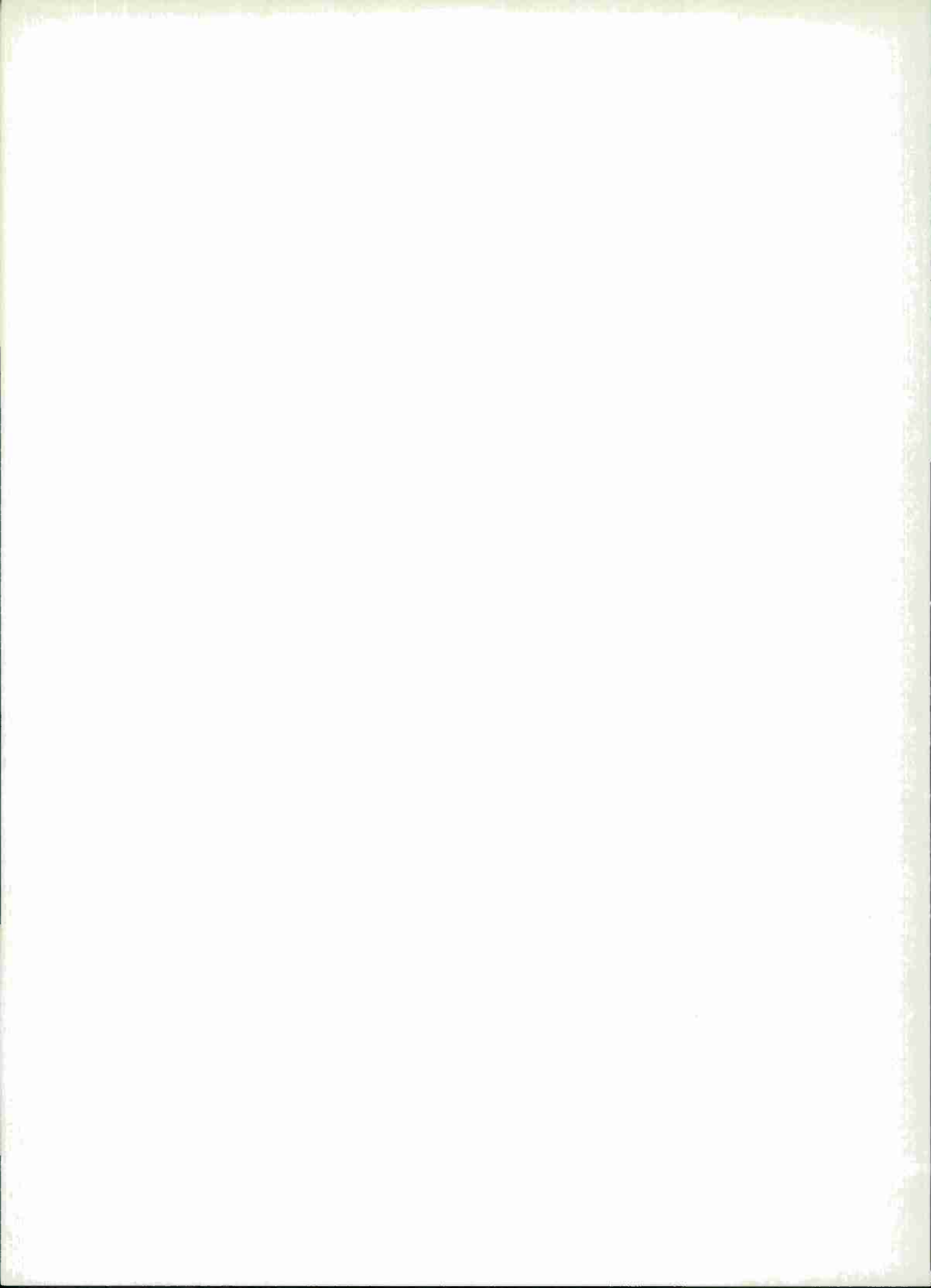
Record Processing Mode

The record processing mode stores specified data items. The program stores historical records of the trainee's path and answers through the lesson in a trainee record table.

The record processing mode requires an authorization to retrieve and access trainee records for processing purposes.

The record processing mode processes the trainee records on an individual basis.

The record processing mode prints stored information in prescribed formats for individual trainees. This information may be output as individual history data and/or summary data.



VIII. CURRENT CDTs DESIGN CONCEPTS

CDTS is currently designed to operate as a standard on-line subsystem, written in COBOL, and functioning under the Burroughs B 3500 Master Control Program (MCP) and Data Communications Handler (DCH).

Base Level On-Line System Environment

Master Control Program. The B 3500 MCP is a modular operating system consisting of a set of routines to provide automatic control over program loading, scheduling, allocation of memory, input/output operations, assignment of hardware components, multiprocessing, and hardware interrupt resolution.

Program Organization Requirements for Execution Under the MCP. Typically, all information pertaining to a program cannot be in core at the same time. CDTS is therefore divided into nonoverlayable and overlayable segments. The non-overlayable segment contains data used most frequently by the program and the program routines required to interface with the MCP. The overlayable segments are brought into core as they are needed. If the program segment is to be overlaid, the code must be reentered.

MCP-CDTS Disk Storage Interface. Disk storage is divided into two categories by the MCP: (1) System Disk; and (2) Users Disk. The System Disk is reserved for the use of MCP and its associated tables and directories. The Users Disk is used to store data files and program files as well as the system compilers. The Users Disk is also divided into permanent and temporary files. A temporary file is one that is declared by the program using it, and is not maintained in the MCP's Disk Directory.

Disk File Organization. Every program must specify the maximum amount of disk required for a particular file. The MCP allows a single file to occupy from one to twenty separate areas on disk. The program that establishes a file specifies the number of areas in the file and the size of the area by defining the number or logical records per area, and the number of areas required. The MCP will allocate disk space only as required during the creation of a file or the lengthening of an existing file.

Disk File Access. The disk file is addressed in 100-byte segments, with all disk file physical records being a multiple of 100 bytes or 200 digits, so that disk space will not be wasted. When a logical record is requested in a random mode, it is addressed by the logical number it has with respect to the first logical record. This method of organization allows the file to be built in a sequential mode and later accessed in a random mode.

On-Line Program System Structure. On-line programs communicate with the MCP for interaction with the remote terminals through the DCH. Each functional system is written as a single COBOL program with an executive/control function as the nonoverlayable program segment and each unique processing routine as overlayable segments. The executive/control function of CDTS is the single Functional System Analyzer (FSA) that communicates with the DCH. The FSA performs analysis of input messages to determine which overlays are needed

to react to the message. When processing is completed and a response prepared, the response is passed to the DCH for output to the remote device.

Input/Output Communications. The DCH performs all direct communications with the remote devices, handles line discipline and error situations, devices, timing considerations, etc.

COBOL Restrictions - Data Communications. The only data communication COBOL constructs that may be used by CDTs are the "FILL FROM" and the "FILL INTO" statements to exchange data with the DCH.

Input/Output Timing. Regardless of message traffic, input messages will be given to CDTs one at a time. This procedure allows CDTs to process each message serially and individually without concern for other remote traffic occurring at the same instant.

On-Line Systems Storage Allocation

Core Storage. On-line systems are currently limited to 32,000 8-bit bytes of core storage. This allocation of memory includes the core-resident portions, (i.e., input/output buffer, data areas, constant areas, FSA, etc.), and the largest overlayable segment required by the system.

Disk Storage. The disk-file storage available with the B 3500 is in modules of 10 million 8-bit bytes, expandable to a maximum of 2.5 billion bytes. There are currently no storage limitations on individual on-line system use of the disk.

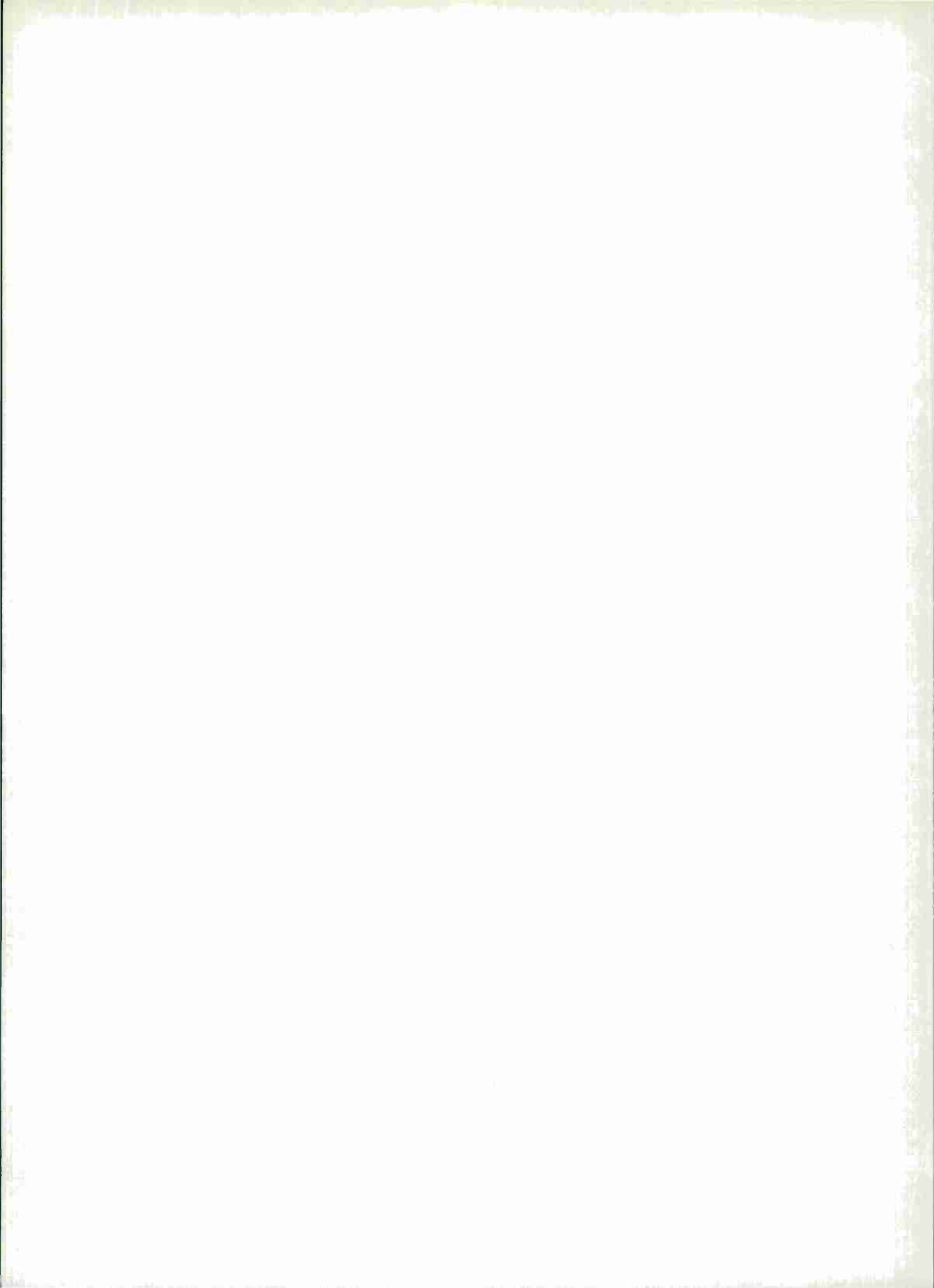
CDTS Storage Requirements Within the Base Level System

Core Storage Requirements:

<u>Program Function Data Area</u>	<u>Core Required (Bytes)</u>
Functional System Analyzer	4,500 (Resident Portion)
User Control Data	2,700
User Data and Working Storage	4,100
Lesson Data	400
Terminal Input Data	400
Cue-Feedback Messages	450
Trainee Record Data	50
Terminal Record Data	168
Overlay Segment Area	<u>21,000</u>
Total	33,868

Disk Storage Requirements. In addition to storage for the program subsystem itself, CDTs requires disk space for the lesson file, the user data file, and the trainee record file. The lesson file contains the lesson data, labels, and directories for each lesson that is to be executed within the particular Phase II Base Level facility. Each 300-frame lesson requires 121,600 bytes of 8-bit byte disk storage. The user data requires 1200 bytes for control

information and 4100 bytes for each user who is in the process of executing a lesson. The trainee display record file (used by the lesson execution function to output records of trainee performance) has, at this time, no fixed storage allocation. Fixing the allocation would require the imposition of a limit upon the number of "frame executions" for a trainee/lesson combination, which is not believed to be feasible at this time.



IX. FEATURES TO BE ADDED TO CDTS

CDTS is designed to perform its input/output functions through a teletype terminal--inputs from an alphanumeric keyboard and outputs a printed page of text. In considering the CDTS Q-45 interface, CDTS will need modifications to 1) recognize inputs from the Q-45 other than the standard alphanumeric keyboard inputs, and 2) generate appropriate output messages to activate the special Q-45 features.

The list of features to be added to CDTS for it to properly interface with the Q-45 is in no way intended to be a comprehensive design specification. Rather, it is a list of the changes required to make CDTS compatible with the Q-45's full communicative capabilities.

The description of these modifications follow and are discussed separately for each of the operating modes of CDTS.

Modifying the Lesson Building Mode

The lesson building mode provides an on-line capability to construct a lesson by permitting the lesson designer to enter course material on a real-time basis. CDTS provides cues to the course designer, guides his actions, and monitors his inputs. The modifications necessary to properly interface CDTS and the Q-45 in the lesson building mode are as follows:

Inputs to CDTS from the Q-45. In addition to inputting textual data via the standard alphanumeric keyboard, the course designer should be able to make direct and indirect use of other Q-45 features. His use differs with the type of group being constructed.

1. Group 2. This is the lesson presentation material. In building this group the course designer is preparing the text, situation, or question to which the trainee is expected to respond.
 - a. Direct
 - . The course designer should be able to use the cursor control to draw and position vectors, points and circles as part of the Group 2 material.
 - . The course designer should be able to manually select a slide as part of the Group 2 material.
 - b. Indirect
 - . Through the use of the alphanumeric keyboard, the course designer should be able to request computer generated vectors circles and points.

- . Through the use of the alphanumeric keyboard, the course designer should be able to select a slide.
 - . Through the use of the alphanumeric keyboard, the course designer should be able to request that any of the program-controlled console lights be turned on.
2. Group 3. These are the anticipated responses made to the stimuli presented in Group 2.
- a. Light gun
- . Through the use of the alphanumeric keyboard, the course designer should be able to indicate that a light gun response is anticipated.
- If the light gun is to be used to select graphic data rather than text, the course designer should be able to identify the correct answer as well as anticipated alternatives. In this case he should be able to describe the answers by type and position.
- b. Variable Function Keyboard
- . Through the use of the alphanumeric keyboard, the course designer should be able to indicate that the trainee response will be made via the variable function keyboard.
- The course designer should be able to identify the correct overlay and key.

Outputs to the Q-45 from CDTS. Since the outputs of the lesson building mode are text, there is no requirement to modify CDTS to provide any additional outputs.

Modifying the Lesson Editing Mode

The lesson editing mode provides an on-line capability of updating lesson material. This mode permits the lesson designer to print, insert or delete any frame, group or line of any constructed course. The modifications necessary to properly interface CDTS and the Q-45 in the lesson editing mode are as follows:

Inputs to CDTS from the Q-45. In addition to making inputs via the alphanumeric keyboard, the lesson editor should be able to use the light gun to identify the group, line, word, or character within a frame that he would like to edit.

Outputs to the Q-45 from CDTS. In addition to the standard textual data output by the lesson editing mode, CDTS should be able to display the directly generated vectors, circles and points. CDTS should also be able to project any manually selected slide.

Modifying the Lesson Execution Mode

The lesson execution mode is the on-line presentation of lesson material to the course designer or trainee. The program controls the sequence of frame presentation as predetermined by the course designer, evaluates actions taken by the trainee, and provides feedback appropriate to his response. The modifications necessary to properly interface CDTS and the Q-45 in the lesson execution mode are as follows:

Inputs to CDTS from the Q-45. In addition to being able to respond via the alphanumeric keyboard, the subject should be able to use the following features of the Q-45:

1. Light gun. The subject should be able to select options offered to him by using the light gun.
2. Cursor control. The subject should be able to use the cursor control to draw and position vectors, circles, and points as required by the lesson.
3. Variable function keyboard. The subject should be able to use the variable function keyboard as required by the lesson.

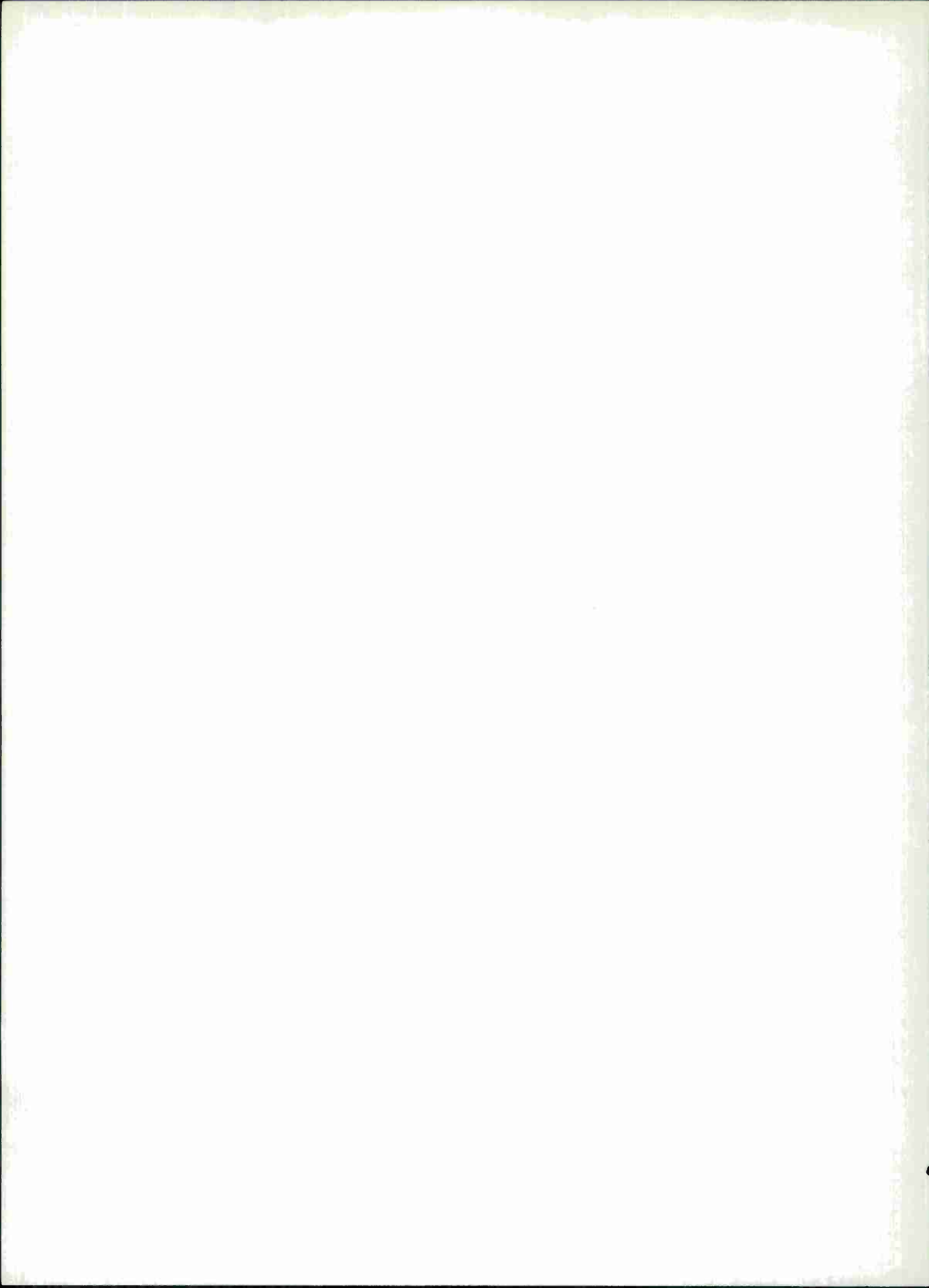
Outputs to the Q-45 from CDTS. In addition to the standard textual outputs of the lesson building mode, CDTS should be able to produce the following outputs:

1. Vectors. As predetermined by the course designer, CDTS should be able to produce a vector or vector string of any legal length and position.
2. Circles. As predetermined by the course designer, CDTS should be able to produce a circle of any legal diameter and position.
3. Points. As predetermined by the course designer, CDTS should be able to produce a point at any legal position.
4. Slides. As predetermined by the course designer, CDTS should be able to select a slide from the slide magazine.
5. Lights. As predetermined by the course designer, CDTS should be able to turn on any of the program controllable console lights.

Modifying the Record Processing Mode

The record processing mode automatically stores historical records of the trainee's path and answers through the lesson. These records are then processed individually at a later time by the appropriate people. The data are printed off-line in a prescribed format.

Due to the off-line nature of the record processing mode, there is no requirement to modify CDTS to provide any additional inputs or outputs in interfacing with the Q-45.



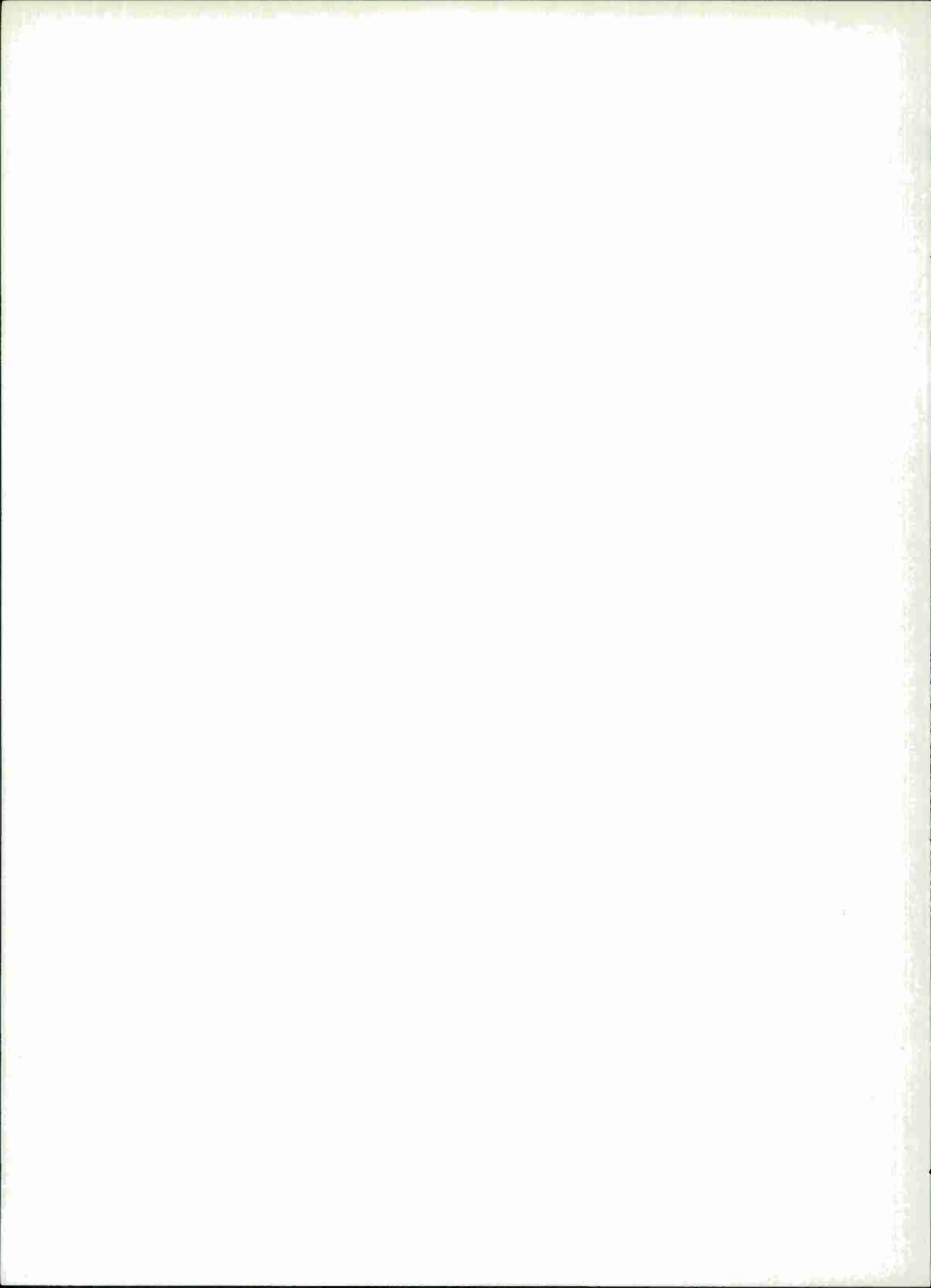
X. MODIFICATIONS TO CDTS PERMITTING THE USE OF THE
AN/FYQ-45 AS ITS PRIMARY I/O DEVICE

In order to determine the feasibility of using the Q-45 as a communication link between CDTS and the user, it was necessary to examine the manner in which the current AFFICS configuration uses the console. The I/O requirements for CDTS for this phase of the study were limited to alphanumeric inputs and textual outputs to permit efforts to be concentrated on minimal interface requirements, rather than system improvements. The current AFFICS configuration contains a Computer Interface Buffer (CIB) that converts the 1410's 6-bit tape-like characters into the Q-45's 12-bit words and vice-versa. The CIB enables the external computer, in this case the 1410, to communicate with the Q-45 as it would a magnetic tape. The CIB in its operation simulates an IBM 729-IV Magnetic Tape Unit.

In the case of CDTS, however, the actual reading and writing of on-line communication devices is performed by the computer's MCP (Operating System) and DCH. (The elements of the COBOL language available to base level on-line systems do not permit direct communication with remote devices.

Regardless of what computer is being used to drive the Q-45, the requirement exists for many programs and programmers to interface with the console. It is safe to assume that to require each programmer to be knowledgeable in the detailed interface with the Q-45 is a situation to be avoided. Thus, the DCH of the Base Level System, or the I/O control program of any computer system would provide capabilities to permit CDTS to interface with the Q-45 in an indirect manner, similar to that currently existing with the remote communications terminals of the B 3500.

Under the above assumptions, the possibility of CDTS interfacing with the Q-45 display console to display standard textual outputs, while accepting inputs in the standard manner from an alphanumeric keyboard, is definitely feasible. The amount of effort directly required to provide the interface would be quite low. However, since CDTS would have to be modified extensively to operate on any computer other than the B 3500, the conclusions of this section cannot be considered independently of Sections XI through XIV.



XI. MODIFICATIONS REQUIRED TO ENABLE CDTS TO OPERATE IN ESD'S IBM 1410 COMPUTER

To operate on the existing ESD Command Control Support Facility, CDTS must be modified to run on an IBM 1410 computer. The characteristics of the ESD experimental facility 1410 configuration of critical importance to CDTS design are:

- . 40,000 6-bit bytes of core storage
- . Four IBM 729 Mod 4 tape units
- . One IBM Model 3 1301 disk unit
- . IBM Disk Operating System
- . COBOL compiler
- . Console Interface Program
- . Computer Interface Buffer

As discussed in Section VIII, CDTS is currently required to operate within a core storage limitation of 32,000 8-bit bytes. As evidenced by the storage requirements outlined on page 48, the CDTS design requirements have already exceeded that limitation. (The net result of this deficiency within the Phase II Base Level System is that the subsystem overlays, optimally sized for processing efficiency, will have to be segmented into two overlays.)

The 1410 configuration used within the ESD facility allocates its 40,000 6-bit byte storage as follows:

- . 15,000 bytes - Console Interface Program
- . 8,000 bytes - Miscellaneous Utility Programs (such as the disk access program)
- . 17,000 bytes - Available for application program such as CDTS

CDTS current design requirements call for approximately 8300 8-bit bytes of core for data storage. Even if a direct transfer of CDTS to the 1410 were possible, only 8 to 9 thousand bytes of storage would be available to house the CDTS control program (FSA under the B 3500) and the overlay area. Elimination, if possible, of part of the resident facility/utility routines currently existing within the 1410 complex would increase this capacity to only 11 to 13 thousand bytes.

As defined in Section VIII, the minimum core requirement for the CDTS overlay segments is 21,000 8-bit bytes (exceeding the B 3500 system capacity by almost 2000 bytes). This indicates that within the core confines of the Phase II Base

Level System, CDTS will be segmented into more overlays than is desirable from the standpoint of system effectiveness. A requirement to almost double the segmentation of the system would not only force a major redesign, but would result in a highly inefficient system.

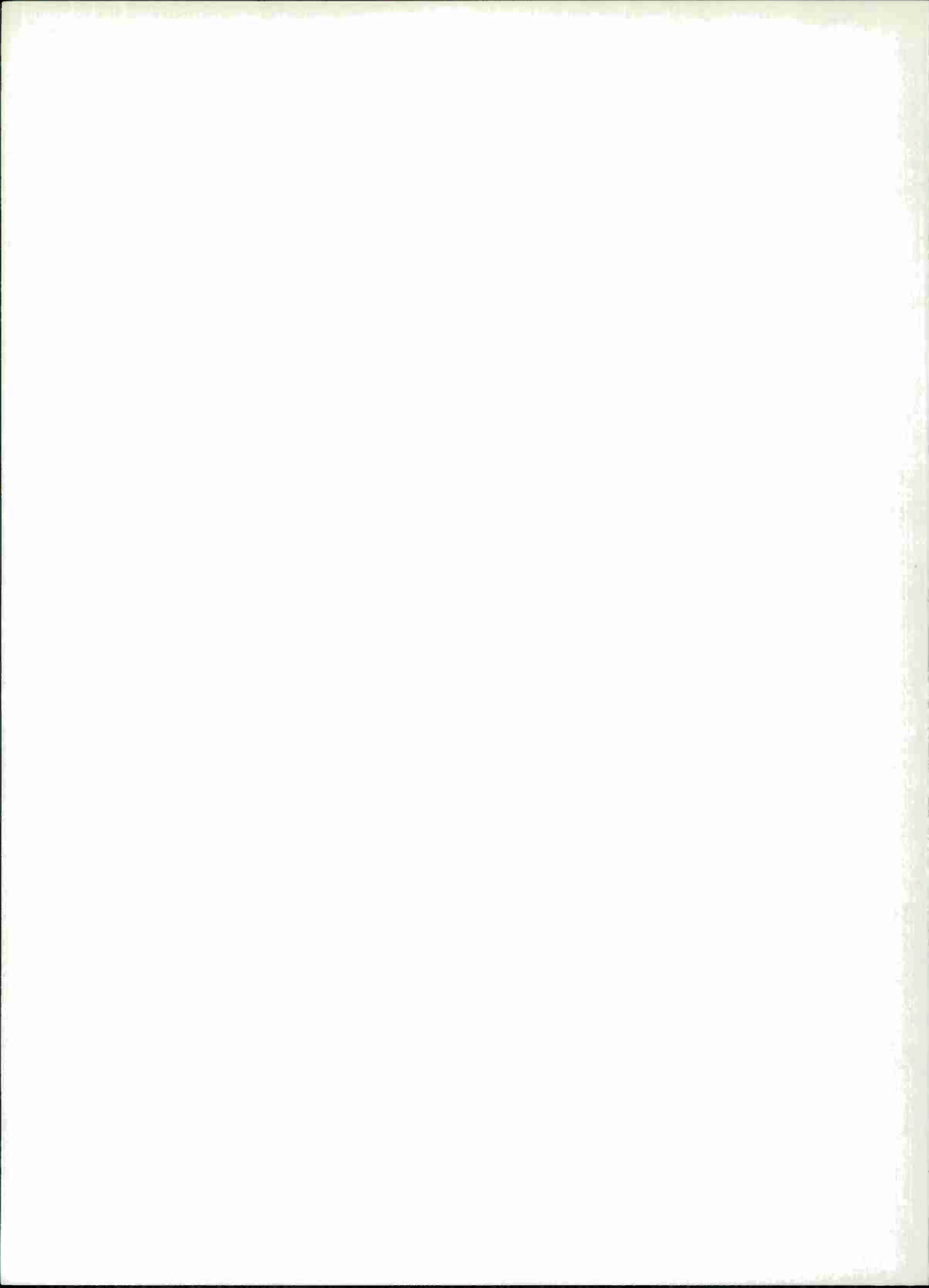
The above factors are further compounded by the relative slowness of the 1410 computer, and its disk system, when compared with typical third generation computers such as the B 3500 or IBM 360 (model 40 and up). It is unlikely that such a system, if it could be developed, would be able to support a training activity having tolerable requirements for student/system response timing.

The analysis above has primarily considered CDTS system storage requirements and computer system speed. The attempt to transfer CDTS to the current ESD Command and Control Support Facility would also be faced with the requirement to modify program design because of the inevitable differences between COBOL compilers on different machines. This alternative is further complicated by the prospect of having to incorporate into CDTS some of the functions currently being performed by the B 3500 MCP and DCH. It becomes evident that providing a computer-assisted instructional capability within the present ESD Command and Control Support Facility is not judged to be feasible.

XII. MODIFICATIONS REQUIRED TO OTHER PROGRAMS TO ENHANCE CDTs TO OPERATE IN ESD'S COMMAND AND CONTROL SUPPORT FACILITY

Currently, programs interfacing with the Q-45 use a special facility program called the Console Interface Program (CIP), which in turn uses the Console Interface Buffer (CIB) to interact with the Q-45. The CIB performs the electronic interface and converts I/O messages to Q-45 format and vice-versa. Use of the Console Interface Program is not actually a required step in the Q-45 interface process. (The interface can be coded directly into the user program.) Analysis of the requirements upon a third generation computer (such as the B 3500 or IBM 360) to interact with the Console Interface Buffer may indeed indicate that it is desirable for individual programs to directly interact with the CIB. It is more probable that the CIB interface requirement would be levied upon the operating system of the third generation machine. As stated in sections III and IV, all CDTs on-line user interaction is accomplished through the operating system and DCH. (The OS 360 provides similar remote terminal interaction capabilities.) It is anticipated that the most desirable approach would be to maintain the simplicity of I/O handling currently afforded all users of these systems and incorporate the CIB interface into the operating system. It is, of course, not possible to assess the magnitude of the required changes to an operating system as a part of this study.

Assuming that the third generation computer used to link CDTs with the Q-45 has a 7-track tape capability, it is unlikely that extensive modifications would be required to the Console Interface Buffer.



XIII. EXPANDED CDTS DESIGN

In the proposed design modification to CDTS, the inherent capabilities of the standard CDTS and Q-45 are used to their greatest advantage to provide a training system that contains the outstanding features of these components. Simplicity of operation is a primary objective of interactive computer systems. For this reason much of the language facility coupled with the special conventions and primitives of the CDTS which optimize user-program interaction remain unchanged. Similarly, the variable function keyboard (VFK) comes into frequent use whenever parameters are not required (e.g. a course designer can establish the service function for phonetic encoding by depressing a display button instead of entering a lengthy expression using the alphanumeric keyboard).

The most important design objective is that the course designer, by building a lesson at the console, has full freedom of use of the Q-45 capabilities in constructing his course material and is able to make use of the on-line editing capability inherent in the console. This enables the course designer to see his course material, as it will appear to the trainee, while it is being constructed. This feature greatly facilitates the task of lesson building.

The following is a description of a system design for CDTS that incorporates the pertinent capabilities of the Q-45. Only those functions that differ from the standard CDTS design are described.

System Initiation

With CDTS in control, the Q-45 in N-mode and random format, the user indicates he wishes to commence program operation by typing in the system command "GET" or "CO" (see Appendix A for a list of proposed functions for the VFK).

To edit or execute an existing lesson, the course designer enters, via the alphanumeric keyboard, "GET XXX" (where XXX is an existing lesson) and depresses the VFK marked "ENTER.*" If he wishes to construct a new lesson, the course designer types in "CO" and depresses the "ENTER" key.

CDTS currently has a limit of 400 characters per frame. For this reason it is recommended that the course designer enter his data to CDTS in small segments rather than the entire frame at once. This will enable CDTS to monitor the inputs more frequently and indicate to the course designer when he is in danger of exceeding the storage capacity.

The Lesson Building Mode

- a. Group One. The course designer is offered a choice of frame types to build: Question, Multiple-choice, Decision or Copy. The design of the decision and copy frames remain unchanged. CDTS displays the Group One (G1) cues to the course designer. They include the frame number and allow him to label the frame if he wishes. If he does, he types in the label of

*Refer to Section VIII for descriptions of the execution and editing modes.

his choice and depresses the "ENTER" key. If a label is not desired, he depresses the VFK marked "GROUP EXIT."

- b. Group Two. The Group Two (G2) displays cue the course designer to enter the text of the frame. The course designer may use all of the Q-45 controls to develop his frame material. That is, the alphanumeric keyboard permits the entering of material at any position on the CRT. The cursor marks the generation and positioning of desired vectors, circles or points. In addition, the course designer can manually select a slide to be projected. Any of the program controlled indicator lights may be turned on by using the "LIGHTS XXX" service function, where XXX is the identification code for the light. The course designer is not limited to combinations of graphics and text and he can use both Page A and B. He must, however, be careful not to exceed the limit of 400 characters per frame. He depresses the VFK marked "ENTER" when the display is the way he wants it. Upon completion of the G2 data the "GROUP EXIT" is depressed.
- c. Group Three. CDTS cues the course designer to enter the Group Three (G3) data. In a question frame, the G3 data are the anticipated responses, while in a multiple-choice frame the G3 data are considered an extension of the G2 data. With the question frame, the course designer types in a letter, followed by the anticipated answer or response by the trainee. If the course designer wishes to input a possible response other than the standard textual response in CDTS, he depresses the appropriate VFK. If the expected response is a graphic display controlled by the cursor control, the course designer depresses the VFK marked "CURSOR," then uses the cursor control to place the vector, circle or point on the scope, and completes the process by depressing the "ENTER" button. The same method would apply with other Q-45 features, with the course designer using other VFKs marked "LIGHT GUN" and "VFK" and then taking the appropriate action. The CDTS service functions PHONETIC and KEYWORD can be turned on in the normal manner, i.e., by typing instructions to turn on the functions. In addition, the functions may be turned on by using the VFK. In either case, the light associated with the PHONETIC or KEYWORD VFKs will be turned on or off, depending on the status of the service function, to serve as a reminder to the course designer. While constructing the G3 material, the course designer may wish to recall which graphic display is associated with an appropriate G3 entry. For this purpose, a VFK entitled "DISPLAY ANSWERS" is provided. When this button is depressed all of the answers will be displayed and the correct one will blink. The course designer can then light gun the letter associated with an answer and the answer, if graphic, will blink. When the course designer has completed entering anticipated responses and identified the correct response with a plus sign proceeding the correct response, he depresses the "GROUP EXIT" button.

When required, it is unlikely that a trainee will be able to position a vector, circle or point exactly. The system will contain a variable parameter to permit approximations to be entered by the trainee which will be evaluated as correct or incorrect responses. This variable parameter will be controlled by a service function "LIMIT XXX" where XXX is the amount of positioning error the course designer considers tolerable.

- d. Group Four. The Group Four (G4) entries form a logical relationship to the anticipated responses entered by the course designer in G3. The G4 entries are the feedback messages to the trainee that relate to his response and branching instructions to control his progress through the lesson. Feedback is normally text and the course designer will be able to position the text anywhere on the scope. When the course designer has completed entering his G4 data, he may proceed to the next frame by depressing the "GROUP EXIT" or "FRAME EXIT" buttons.

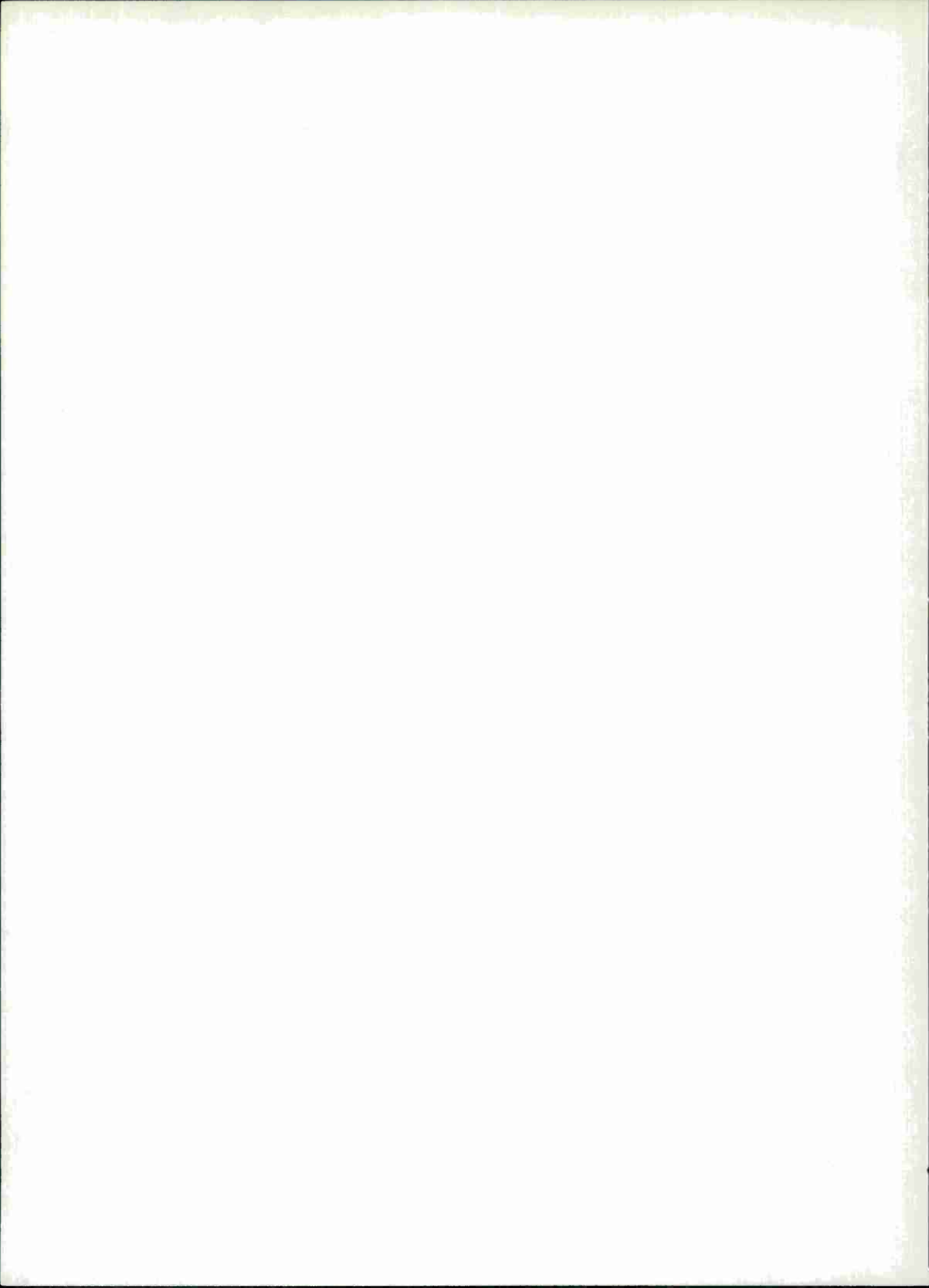
The completed frame is stored as an entity on disk, along with the console status at the time of frame exit. Normally, the display is then cleared in preparation to build the next frame. If, however, the VFK marked "RETAIN PREVIOUS FRAME" was depressed before the "FRAME EXIT" button, the display will not be cleared. This permits the course designer to build a logical frame which exceeds the 400-character-per-frame limit.

The Lesson Editing Mode

In the editing mode, CDTS will take advantage of the inherent editing capabilities of the Q-45. The course designer, once he has requested the lesson he wishes to edit with a "GET XXX," where XXX is the name he has assigned to the lesson, can cause any frame to be displayed. He then makes any deletions, additions or changes to the frame and depresses the "ENTER" button and the updated frame replaces the original frame on the disk. He can then call up another frame by frame number, or he can take the next frame in sequence by depressing the VFK "ADVANCE FRAME". When a new frame is called up, the display area will be cleared of residual data, except when "ADVANCE FRAME" is used and the "RETAIN PREVIOUS FRAME" indicator is set. When a frame is called up, the console status is restored to the condition when the frame was built.

The Lesson Execution Mode

In this mode, the previously generated course material is presented to the trainee. CDTS positions the lesson to the proper frame depending upon whether the trainee is starting or continuing the lesson. The course material, in this case the console display and status, is retrieved and reconstructed to the condition at the time the lesson was built. Page A and B will be restored as well as page selection, slides will be projected, and indicator lights will be turned on. The data contained in G3 are processed and displayed in multiple-choice alternatives, otherwise the data are not displayed. After processing G3 data, CDTS waits for a response by the trainee. The trainee may be asked to respond via the alphanumeric keyboard, the light gun, the VFK, or the cursor control. Once he has done this and "ENTERED" his answers, CDTS evaluates his response and gives him feedback (G4 data) appropriate to his actions. If the trainee is asked to position a vector, circle or point on the scope, the variable parameter "LIMIT" is used to determine whether the positioning error is within allowable limits.



XIV. ALTERNATE METHODS FOR IMPLEMENTING CDTS WITHIN THE ESD COMMAND AND CONTROL SUPPORT FACILITY

Because it was found impractical to implement CDTS within the existing hardware at the ESD Command and Control Support Facility, several alternatives were considered.

The Burroughs 3500, for which CDTS is currently being written, was given careful consideration. The B 3500 can be used as a time-shared computer, with the ESD Command and Control Support Facility as a remote user of the Hanscom AFB Phase II Base Level computer, or as a dedicated machine located within the ESD facility.

The obvious advantage to the use of the B 3500 is that a complete redesign of CDTS is not required. CDTS is being written for the B 3500 in COBOL so that the only changes necessary would be to incorporate the modifications indicated in Section XIII. This alternative then appears to be the least expensive in terms of program modification. It is estimated that this could be installed in CDTS by a 20 man month activity, expended over a ten month period. However, it is projected that the work load levels of the Phase II Base Level computers will reach capacity and thereby make it questionable to expand CDTS to incorporate the necessary changes. If the ESD Command and Control Support Facility is to use a B 3500 computer, strong consideration should be given to using a B 3500 not dedicated to the Base Level System.

As stated above, the reprogramming of CDTS to interface with the Q-45 via the B 3500 will involve a substantial amount of effort, but not require a complete redesign. With a dedicated machine, additional modifications could be made to CDTS to improve efficiency. The program is currently designed to simultaneously service multiple remote terminal users. Data areas and bookkeeping routines could be redesigned to more efficiently handle the interaction with a single Q-45 console. The CDTS control program would be extensively modified, with many routines eliminated and core storage requirements reduced. The reduced core requirements could in turn be capitalized upon by expanding the lesson frame size, resulting in an additional increase in operating efficiency. These modifications could be provided by a 6 to 8 man month programming effort.

Another approach to the selection of a computer is to recognize that the ESD Command and Control Support Facility may be affected by the pending WWMCCS purchase. JOVIAL has been selected as the official command and control programming language. This language is more adaptable than COBOL to interactive programming where more precise control of data handling is required.

While a COBOL compiler may be available on the WWMCCS computer, CDTS could not be compiled and executed on a different machine without reprogramming. The different operating system, machine word/byte structure, restrictions and capabilities involving application programs would make this a sizable effort.

It is estimated that the task of redesigning, recoding, and checkout of CDTS in JOVIAL could be accomplished in approximately a 50 man month effort. The

system could be designed and developed within a span of 12 months.

Obviously, the initial programming costs to provide a Q-45 capability within CDTS under JOVIAL would be higher than with the B 3500. However, the projected capacity and increased operating efficiency of the WWMCCS computer could make this the most desirable alternative.

XV. SUMMARY AND CONCLUSIONS

ESD has as one of its objectives an improved system for on-the-job training and performance support of Staff and Command officers, programmers, and other computer users who will work in future command and control systems.

To this end, information was gathered for an experimental computer-aided training subsystem which can be used as a support capability for research and development activities in the ESD Command and Control Support Facility.

A feasibility study was conducted to establish requirements for modifying the Computer-Directed Training Subsystem (CDTS) being developed through Air Force Contract FL9628-67-C-0427.

A brief survey was performed of four representative systems--SACCS, AFICCS, NOCOPS, and DELTA--to determine the current personnel functions from which future personnel functions could be projected. As a means of guiding and structuring the survey, an initial distinction was made between operational and system support functions. Within this dichotomy, further segmentation was established. Control and command differentiates operational functions. Personnel functions considered critical were delineated and subjected to an examination for possible adaptation of computer-aided training strategies and methods.

The ESD Command and Control Support Facility was examined to determine whether a computer-aided training subsystem could be implemented within the existing environment. CDTS served as the model from which conclusions were derived.

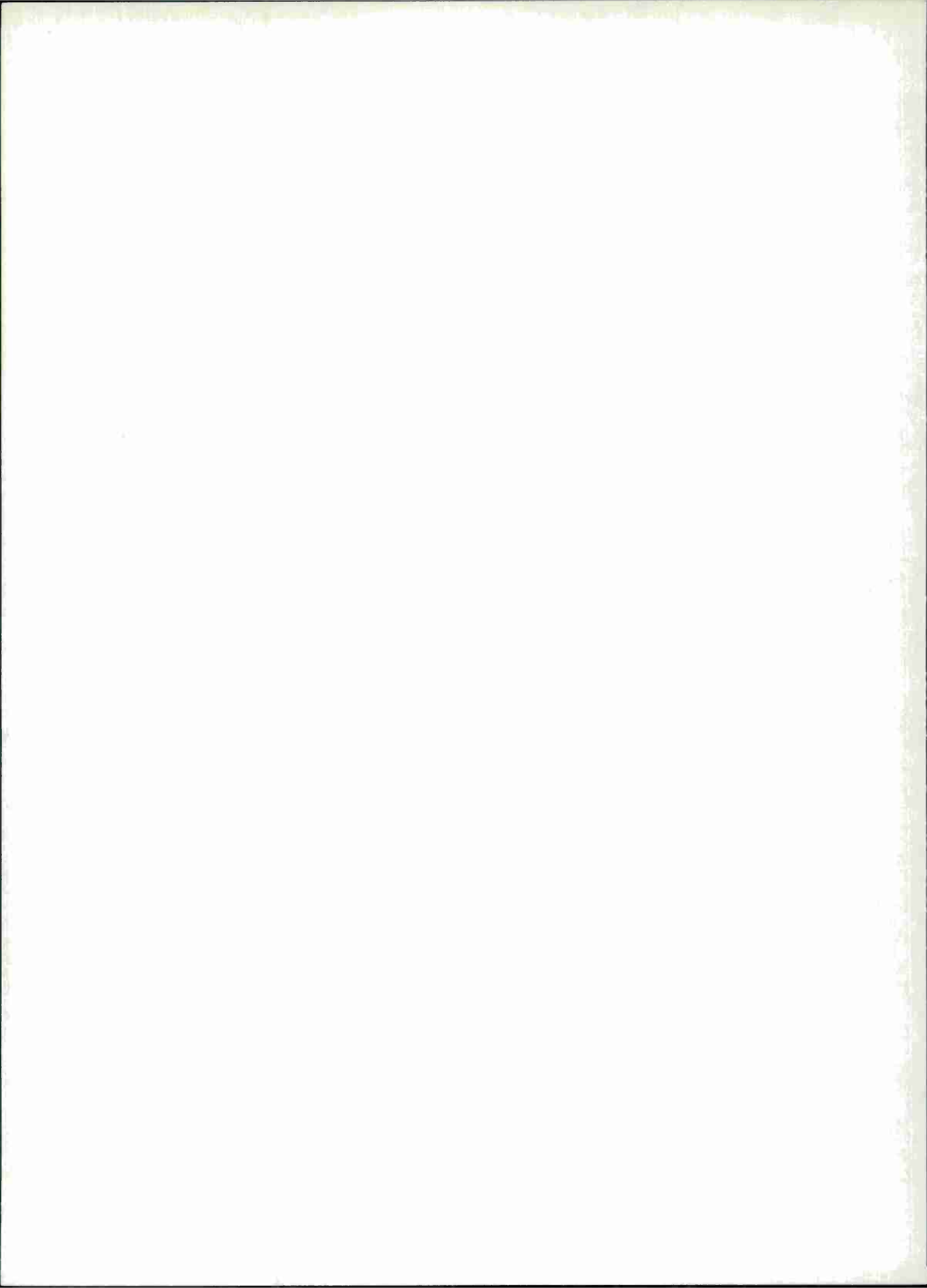
Because of the many technical problems set forth in Section XI, it was concluded that it would not be feasible to provide a computer-assisted instructional capability within the present ESD Command and Control Support Facility. There are, however, alternate approaches, listed in increasing order of cost-effectiveness, as follows:

- . Modification of CDTS to fully utilize the capabilities of the Q-45 while operating within a currently scheduled Phase II Base Level B 3500 System.
- . Modification of CDTS to fully utilize the capabilities of the Q-45 on a B 3500 System which would be dedicated to the data processing requirements of the ESD Command and Control Support Facility.
- . Redesign and recoding of CDTS in the JOVIAL programming language to interface with the Q-45 and operate on the WWMCCS computer to be installed within the ESD facility.

As conveyed in Section XIV, the initial programming costs to provide a CDTS/Q-45 training subsystem would be the greatest under the third alternative. However, the long-range advantages, resulting from the projected capacity and increased operating efficiency of the WWMCCS computer, make this the most desirable alternative.

XVI. REFERENCES

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- System Development Corporation. Performance/Design Requirements and Detailed Technical Description Computer-Directed Training Subsystem for Air Force Phase II Base Level System, by A. K. Butler, R. S. Cowdery, J. W. Cullen, D. K. McBane, and L. D. Peshek. (TM-(L)-3724/001/00 DRAFT) June 7, 1968.



APPENDIX A. VARIABLE FUNCTION KEYBOARD

LESSON BUILDING AND EDITING MODES

- ENTER - Transmit new data from Q-45 to external computer for processing, validity checking, and storage.
- RETAIN PREVIOUS FRAME - Do not clear display before building next frame. Allows the Course Designer (CD) to build a logical frame larger than CDTs capacities permit.
- ANSWER TYPE:
- TEXT (Standard Mode) - When depressed, indicators will light. This indicates that the CD intends to input an anticipated answer via the alphanumeric keyboard (text).
- LIGHT GUN - When depressed, indicators will light. This indicates that the CD intends to input an anticipated answer by taking a light gun action.
- VFK - When depressed, indicators will light. This indicates that the CD intends to input an anticipated answer by depressing a key on the VFK.
- CURSOR - When depressed, indicators will light. This indicates that the CD intends to input an anticipated answer by placing a point or circle or drawing a vector via the cursor control.
- PHONETIC ON - When depressed, indicators will light. This turns on the PHONETIC service function of CDTs. A second depression of button will turn PHONETIC off.
- KEYWORD ON - When depressed, indicators will light. This turns on the KEYWORD service function of CDTs. A second depression of the KEYWORD button will turn the function off.
- GROUP EXIT - When depressed, this indicates that the CD is through entering data for the group being built and wishes CDTs to prepare itself for inputs for the next group.
- FRAME EXIT - When depressed, this indicates the CD is through entering data for the frame being built and wishes CDTs to prepare itself for inputs for the next frame

DISPLAY ANSWERS

- When depressed, all graphic anticipated answers for the current frame will be displayed and correct answer will blink. If desired, the CD may light gun any of the letters associated with answers causing the applicable display to blink.

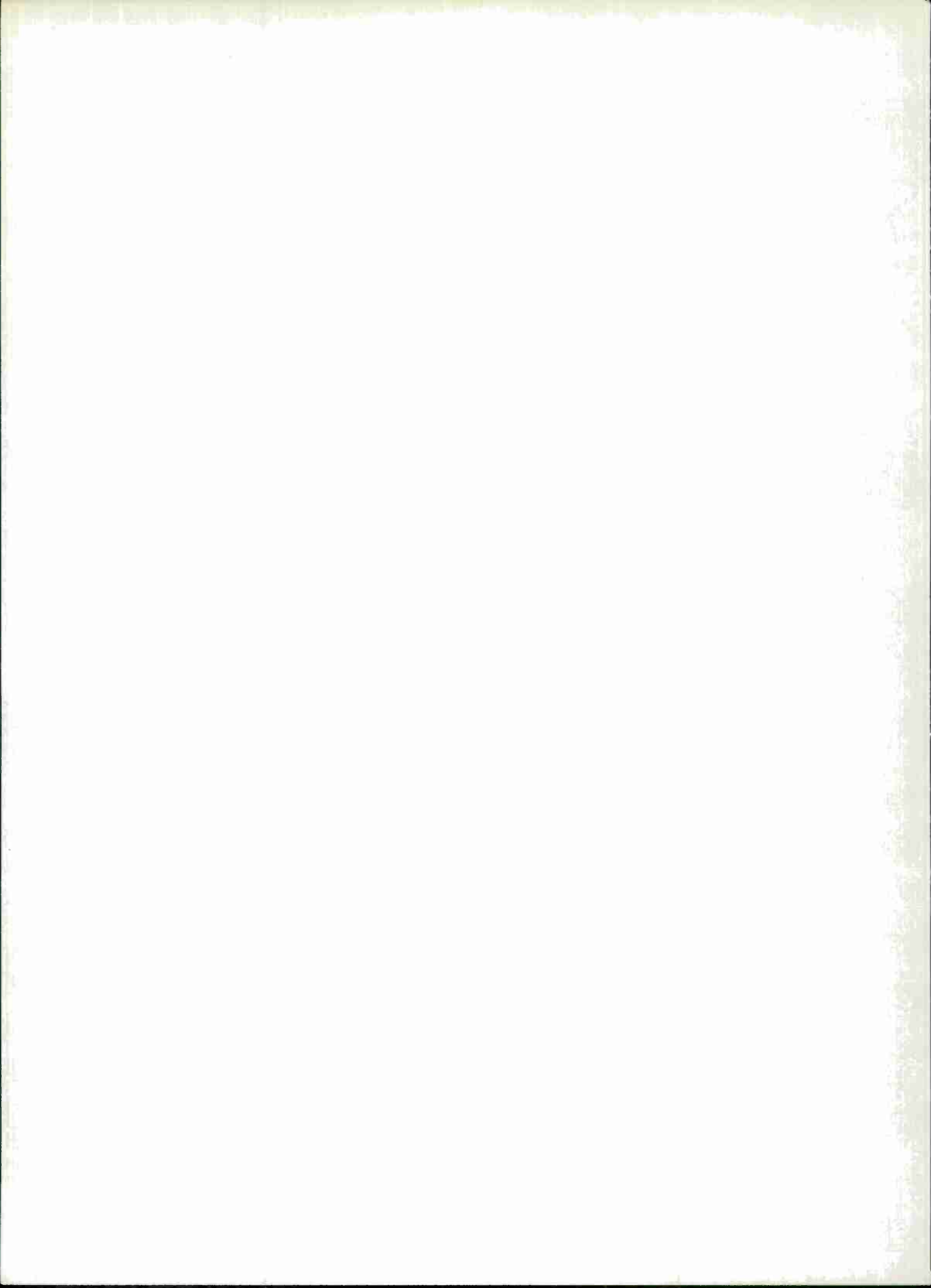
EDITING MODE ONLY

ADVANCE FRAME

- When depressed, the next frame in sequence will be displayed on the CRT.

APPENDIX B. CDT'S OVERLAYS FOR THE VFK

1.	ENTER	16.
2.	RETAIN PREVIOUS FRAME	17.
3.	TEXT	18.
4.	LIGHT GUN	19.
5.	VFK	20.
6.	CURSOR	21.
7.	PHONETIC	22.
8.	KEYWORD	23.
9.	GROUP EXIT	24.
10.	FRAME EXIT	25.
11.	DISPLAY ANSWERS	26.
12.	ADVANCE FRAME	27.
13.		28.
14.		29.
15.		30.



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13. ABSTRACT <p>This document presents the findings of a research study on a computer-aided training subsystem for USAF command and control personnel. In this study, two major tasks were performed. The first was the identification of critical personnel functions in current and projected command and control systems and the applicability of advanced training strategies and methods for on-the-job training. The second was to determine the feasibility of applying these strategies and methods through a computer-directed training subsystem within the Electronic Systems Division (ESD) Command and Control Support Facility. The Computer-Directed Training Subsystem (CDTS), currently under development at SDC through Air Force contract FI9628-67-C-0427, served as the basic system. Information was developed to determine the additional features and modifications that would enable CDTS to operate within the ESD environment and make use of the communicative capabilities of the AN/FYQ-45 graphics console.</p>			

14.	KEY WORDS	LINK A		LINK B		LINK C	
		ROLE	WT	ROLE	WT	ROLE	WT
	Computer-Aided Training Computer-Directed Training Phase II Base Level System Command and Control CDTS AN/FYQ-45 Personnel Functions Support Facility World Wide Military Command and Control System WWMCCS On-Line Graphic Display						

